US Army Corps
of Engineers
St. Paul District

HYDRODYNAMIC CONDITIONS IN THE BLACK RIVER DELTA/LAKE ONALASKA AREA, POOL 7, UPPER MISSISSIPPI RIVER 1980-81 and 1991-92

AUGUST 1994

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Lake Onalaska is conncected to the main channel of the Mississippi River and to the Black River by a network of secondary and distributary channels. Concerns have developed that changes in the flow conveyance of these channels, due to erosion and deposition, is altering the long term distribution of water in Lake Onalaska; with the ration of Mississippi River to Black River water increasing. Maintaining or decreasing this ratio is desirable due to the better water clarity of the Black River. To quantify these changes, water discharge and water surface elevation data was collected in 1991 and 1992. The unanswered question is whether there is a longterm trend towards decreasing Black River flow to Lake Onalaska. The data collected in 1991/92 provides a baseline by which this trend can be verified in the future.

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CONVERSION FACTORS

Multiply	By	To Obtain
cubic feet per second (cfs)	0.02832	cubic meters per second
miles	1.609	kilometers
square miles	2.590	square kilometers
feet per second (fps)	0.305	meters per second
square feet	0.093	square meters

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ABSTRACT

Lake Onalaska is connected to the main channel of the Mississippi River and to the Black River by a network of secondary and distributary channels. Concerns have developed that changes in the flow conveyance of these channels, due to erosion and deposition, is altering the long term distribution of water in Lake Onalaska; with the ratio of Mississippi River to Black River water increasing. Maintaining or decreasing this ratio, is desirable due to the better water clarity of Black River water. To quantify these changes, water discharge and water surface elevation data was collected in 1991 and 1992. This effort confirmed that Mississippi River inflows to Lake Onalaska increased 10-percent between 1980-81 and 1991-92. It also shows that the majority of Black River water enters Lake Onalaska. Dodge-2 is currently the largest distributary of the Black River Delta, and has replaced upper Dodge Chute as the primary source of Black River water to Lake Onalaska. Water surface elevations in the Black River Delta are highest along the main stem, indicating a potential for lateral breakout flows and new channel formation. However, existing bridges, which act as channel controls, apparently limit this process. The main unanswered question is whether there is a longterm trend towards decreasing Black River flow to Lake Onalaska. The data collected in 1991-92 provides a baseline by which this trend, or a lack of one, can be verified in the future.

INTRODUCTION

Pool 7 of the Upper Mississippi River can be divided into three primary hydrodynamic areas: the Mississippi River main channel on the west side of the valley; and on the east side, the Black River delta in the upper pool, and the open water of Lake Onalaska in the lower pool (Figure 1). A network of secondary channels provides hydraulic connections between these three areas. Concerns exist that fluvial changes are causing the long term distribution of water in Lake Onalaska to change; with the ratio of Mississippi River to Black River water increasing. Because of these concerns, this study was initiated. The focus of this study is to assess past and present hydrodynamic conditions in the Black River Delta/Lake Onalaska systems. The two parameters monitored were channel discharge and water surface elevations.

The Black River enters the Upper Mississippi River between river miles 708 and 712. The dominant river planform in the lower 10 miles of the Black River is complex deltaic with numerous distributary channels splitting off from the

main stem sediment ridge. Currently there are five major distributary channels; Dodge Chute, Bullet Chute, Duckhead Chute, Tank Creek, and Shingle Creek. These channels transport water and sediment from the Black River main stem to the Mississippi Valley. Of the 277,000 tons of sediment transported past Galesville, WI (13 miles upstream) annually, 57-percent is transported as suspended sediment and 43-percent is transported as bedload (Rose 1992). Particle size analysis indicated that over 75-percent of this sediment was sand. Because of the high percentage of sand, channel aggradation with subsequent migration and eventual abandonment is common. This process was described by Chow (1964) for reservoir situations.

> *In wider valleys the delta form becomes more complex. Under such conditions the sediment ridge extends into only a portion of the pool. In time, the ridge will extend above normal pool level and develop a reduced slope. Subsequent floods breach the natural levees adjacent to the channels, resulting in development of a new channel and ridge over fines previously deposited in the headwater area. Most deltas in reservoirs are of the complex type.*

A couple of recent examples of the dynamic character of the Black River Delta exist. For instance, between 1973 and 1989 the lower reach of Bullet Chute changed locations as shown on Figure 2. Another example is upper Dodge Chute which had occluded by 1986, preventing low flows through this channel. However, this coincided with an increase in the size and hydraulic conveyance of Dodge-2 which eventually joins Dodge Chute.

Downstream of the Black River Delta is Lake Onalaska a shallow (4 to 5 foot depths typical), 7,500 acre backwater lake. Formerly Lake Onalaska was a seasonally flooded bottomland segmented by channels of the Black River which flowed through its eastern half. Construction of Lock and Dam 7 in 1937 inundated the entire area. The result was the formation of a lake that receives water from two primary sources: the Mississippi River through several channels leading from the main channel and the Black River (Claflin 1977). A long chain of natural and dredge material deposits adjacent the main channel form barrier islands between Lake Onalaska and the main channel. Previous studies indicated that for river discharges up to 100,000 cfs, 30-percent of the Mississippi River water entered Lake Onalaska through seven secondary channels cut through the barrier islands. The largest of these channels, Sommers Chute, accounted for approximately 80-percent of the water exchange between the rivers and the lake where the cumulative flow (Mississippi River and Black River) is 100,000 cfs or less (Pavlou et al. 1982, Dexter et al. 1978). At river discharges greater than 100,000 cfs, the barrier islands are overtopped and the amount of water entering Lake Onalaska increases. During the summer flood of 1993, USCOE measurements indicate that 52-percent of the total river discharge was conveyed through Lake Onalaska. In many reaches of the Upper Mississippi River, there exists a longterm trend of increasing hydraulic conveyance through backwater areas due to secondary channel erosion. This is the case in Pool 7. Secondary channel erosion with increased Mississippi River inflows prompted construction of rock lined partial closure structures at Bullet and No Name Chutes in 1989 as part of the Winters Landing Navigation Channel Project. At Sommers Chute, erosion has increased flows to Lake Onalaska and caused navigation problems for commercial vessels passing this site. To remedy this, the USCOE plans to construct a submerged rock weir to reduce inflows. Rock liners will also be used to stabilize Goose, Gibbs, and Proudfoot Chutes. Black River water enters Lake Onalaska in one of two ways; directly by flowing through distributaries that lead into the upstream

end of the lake (ie. Dodge Chute, Bullet Chute), or indirectly by flowing through distributaries entering the Mississippi River first (ie. Duckhead Chute, Shingle Creek, Tank Creek) and then entering the backwaters via one of the secondary channels. Water quality in the Black River Delta/Lake Onalaska system is strongly affected by the distribution of Mississippi and Black River water, with Black River water usually being less turbid and more desirable. Short term flow distributions are a function of hydrologic conditions on either river, while long term distribution is a function of erosion or sediment accretion in secondary channels.

The terms main, secondary, tertiary, and distributary are used in this report to describe channels. In pool 7, the main channel is on the west side of the river valley and contains the navigation channel. Secondary channels are those that convey water from the main channel into the backwaters (ie. No Name Chute, Sommers Chute). In the Black River Delta, the main channel (also referred to as main stem) is the channel that flows under the bike trail and BNRR bridges near Lytles. After passing under the bridges this channel quickly splits into distributary channels Dodge Chute, Dodge 2, Bullet Chute, and Duckhead Chute, which further split into unnamed tertiary channels. In deltas, the term distributary is used in favor of secondary.

STUDY AREA DEFINITION

The primary study area includes; the Black River delta and Pool 7 of the Mississippi River (Figure 1). The Black River with a drainage area of 2,250 square miles is the only large tributary entering the Mississippi River in this reach. There are numerous projects in the Black River/Lake Onalaska Area which have been constructed or are in various study or design stages. These are listed in Table 1.

METHODOLOGY

Secondary Channel Discharge Measurements

Discharge measurements collected by USCOE personnel were done from a 20-foot Pontoon boat using a type-AA Price current meter. Boat position was determined using a Cubic Precision, Pulse Ranger, electronic distance meter. A Loran-C positioning system was employed on a number of occasions also. Depending on channel geometry the methods employed to maintain a stationary boat position included: a tag line (cable stretched across the channel), boat anchors, or spuds (vertical poles placed through sleeves on the boat and into the bottom). Channel discharge was determined by dividing the cross section into variable width subsections as recommended by the USGS (Buchanan and Somers 1969) with the exception that the number of subsections used at each cross section usually was limited to about ten. In each subsection the water depth (feet) and velocity (feet per second) at 8/10 and 2/10 depth was determined. If the water depth was less than 2.5 feet, a single velocity measurement was taken at 6/10 depth (measured from the surface). In each subsection, the cross sectional area (square feet) was determined by multiplying the water depth by the width, and the average velocity was determined by calculating the average of the 8/10 and 2/10 depth velocity readings (or by using the measurement at 6/10 depth). When the streamlines weren't perpendicular to the cross section line, the average velocity was reduced by the sine of the acute

Table 1. Existing and Future Projects in the Black River/Lake Onalaska Area.

Project	River Mile	Const. Date	Purpose	Main Features
Brice Prairie Channel	705.5	1967	provide flow from Dodge Chute to newly constructed Brice Prairie Channel	channel dredging
Lake Onalaska HREP	705.0	1989	fisheries. improve growth of aquatic vegetation	channel dredging island construction.
Winters Landing Navigation Channel Improvement	708.0-709.3	1989	reduce dredging; stop erosion and reduce inflow from Mississippi River to Bullet and No-name Chutes	realign navigation chann rock-lined channels.
Brice Prairie Island Stabilization	705.5	1992	shoreline stabilization	rock shoreline protection
Lake Onalaska HREP Island Stabilization	705.0	1993	stabilize HREP islands	rock shoreline protection.
Onalaska Spillway Rehabilitation	702.5	1994-1995	rehabilitation of existing dam	spillway rehab. new conduits. cofferdam.
Dakota Navigation Channel Improvement	705.5-707.5	1994	improve navigation stabilize secondary channels	rock-lined channels wing dam repair
Long Lake HREP	712.7	(3)	provide oxygenated flow to Long Lake	channelization. control struct.
French Lake Aeration Culvert	702.5	1994	provide oxygenated flow to downstream backwater area	gated conduit through Lock and Dam 7 dike
Red Oak Island Stabilization	703.5	1995	stabilize eroding island	rock shoreline protection.
Bank Stabilization HREP	702.7	1997	stabilize eroding islands	rock shoreline protection.
East Channel, Smith and French Slough HREP	700.5-702.0	1998	fisheries, bank stabilization	channel dredging rock shoreline protection

Note: (1) HREP stands for Habitat Rehabilitation and Enhancement Project which are constructed through the Environmental Management Program (EMP).
(2) This is a monitoring effort to assess island impacts and will be done throughout the Lake Onalaska area in 1993.
(3) The Long Lake HREP is currently on hold.

angle between the streamline and the cross section line. The subsection discharge (cubic feet per second) was determined by multiplying the subsection area by the average velocity and the total cross section discharge was calculated by summing the subsection discharges. Similar techniques were used by other investigators.

WDNR personnel used similar techniques for collecting discharge measurements in 1991 and 1992 with only a few differences. For measuring current velocity, a Marsh-McBirney model 201D electromagnetic current meter was used. At bridge sites, measurements were obtained by suspending the meter from the bridge. Information on the methodology used for collecting discharge data in 1980-81 wasn't available.

Discharge measurement errors are a function of several factors. At velocities less than 0.2 fps, the accuracy of the Price Meter decreases. Wind and waves may cause vertical and horizontal boat movement resulting in errors in measured velocities which tend to be magnified for low flow conditions. An analysis of these errors is found in Kalio (1966). Large commercial vessels may temporarily change secondary channel discharges. And lock and dam operation may affect local hydrodynamics. In addition, discharge at a site can change over time due to aquatic vegetation density, and sediment deposition or erosion. As a check on discharge measurement integrity, the calculated lock and dam discharge is compared to the measured discharge in the adjacent pool on those occasions when the data collection effort results in measurement of the total river discharge. These comparisons are summarized in Table 2. The

Table 2. Comparison Between Measured Total River Discharge and Total River Discharge Calculated at Lock and Dam.

Lock and Dam Discharge Range (cfs)	Lock and Dam Average Discharge (cfs)	Total Measured Discharge (cfs)	Difference (%)	Date	Location	Lock and Dam used
18,600 - 18,700	18,600	18,565	0.2	8/22/91	Pool 3	3
64,700 - 66,550	65,705	59,425	9.6	3/31-4/01/92	Pool 5	5
23,650 - 25,900	24,600	23,257	5.5	8/27-8/29/91	Pool 5A	5A
69,525 - 70,700	69,916	63,725	8.8	8/12-8/13/93	Pool 5A	5A
77,400 - 86,600	81,581	74,701	8.4	4/02-4/04/91	Pool 7	7
60,150 - 61,825	60,771	57,691	5.1	4/15-4/17/91	Pool 7	7
35,525 - 36,400	35,923	32,147	10.5	8/06-8/07/91	Pool 7	7
31,150 - 42,600	37,544	37,846	0.8	9/10-9/12/91	Pool 7	7
55,500 - 56,500	56,029	58,089	3.7	7/14-7/15/92	Pool 7	7
20,400 - 20,500	20,438	22,517	10.2	9/23-9/25/87	Pool 8	8
116,300 - 117,400	116,864	109,605	6.2	4/21-4/22/93	Pool 8	8
81,300 - 82,150	81,761	86,513	5.8	5/03-5/05/93	Pool 8	8
77,850 - 79,800	78,850	89,870	14.0	6/14-6/18/93	Pool 8	8
72,100 - 72,800	72,396	63,031	12.9	8/05-8/07/93	Pool 8	8
47,350 - 51,200	48,193	43,050	10.6	9/21-9/23/93	Pool 8	8
27,400 - 28,750	27,765	22,126	20.3	11/3-11/5/93	Pool 8	8
75,900 - 76,625	76,263	74,414	2.4	8/02/93	Pool 9	8
170,550 - 172,025	171,400	148,764	13.2	7/07/93	Pool 9	9
53,475 - 55,450	54,483	51,952	4.6	9/22/93	Pool 10	9

difference between measured discharge and the average lock and dam discharge ranged from 0.2-percent to 20.3-percent, with a mean of 8.0-percent. The measurements done between June and November, 1993 in pools 8 and 9 differ significantly with those recorded at the lock and dam; in most cases the measured discharge being lower than the lock and dam discharge. The estimated discharge at lock and dam 8 was used for these comparisons except for the 7/7/93 measurement in Pool 9. It appears that significant errors exist in either the measured discharge or the estimated Lock and Dam 8 discharge. No effort has been made to correct the measured data based on these differences.

Because the total Mississippi River or Black River discharge can change significantly over the length of time required to collect a full set of discharge measurements, it was usually not possible to directly measure the total discharge into the Lake Onalaska/Black River complex from either river. Rather, discharge curves for each secondary channel were developed from data pairs of secondary channel discharge versus total river discharge on the Mississippi River at Lock and Dam 6 or on the Black River at Galesville, Wisconsin for the date of measurement. Discharge curves for the total discharge into the Lake Onalaska area were then developed by summing the discharges obtained from the discharge curves for the individual secondary channels.

Mississippi River/Black River Discharge

Lock and Dam 6 (Trempealeau, WI) discharges are determined on-site and transferred to the St. Paul District WCC (Water Control Center) each day. Discharges for the 1991-92 monitoring effort were available on a 4 hour interval, however only 8 AM Lock and Dam 6 discharge readings were available for the 1980-81 period.

Discharge readings at the USGS (United States Geologic Survey) gage at Galesville, Wisconsin represent the mean daily discharge. The Black River at the monitoring site at the U.S. Highway 53 crossing near Galesville is about 13 river miles upstream (north) of where the river enters Lake Onalaska. The watershed area upstream from the monitoring site is 2,080 square miles and comprises 92-percent of the watershed upstream from Lake Onalaska (Rose, 1992).

Water Surface Elevations

Water Surface Elevations (NGVD, 1912 adj.) in Pool 7 are measured at River Mile 702.7 (Lock and Dam 7 upper guide wall), River Mile 707.3 (Dakota Gage), and at River Mile 714.1 (Lock and Dam 6 lower guide wall). Data is recorded at 4 hour intervals and transferred to the St. Paul District WCC each morning by 7:30 AM. This data is collected manually at the Locks and Dams and through the use of a DCP (data collection platform) at the control point.

Water surface elevations in the Black River delta have been monitored by the Lake Onalaska Protection and Rehabilitation District and the WDNR. Staff gages for this were set and tied into temporary bench marks (TBMs) in July 1991. Vertical datum (NGVD, 1912 Adjustment) for these gages and TBMs was determined by Corps personnel based on surveys done in February 1992. The gages were reset and tied into the TBMs in 1992. A description of gage/TBM location and surveys is contained in Appendix A. The stage-discharge curve for the USGS gage at Galesville, Wisconsin was used to determine water surface elevations at this site.

Aerial Reconnaissance

Aerial reconnaissance to observe flow patterns was done in a chartered, single engine, high wing, aircraft. Oblique aerials are taken as a record of flow patterns on flight days.

DATA MANAGEMENT

Discharge Measurements

Discharge measurements currently are archived on a data base system maintained on an AT&T 3b2-1000 mini-computer by the St. Paul Districts Hydraulics Section. Data pairs of secondary channel discharge versus Black River discharge at Galesville or Mississippi River discharge at Lock and Dam 6 or 7 are stored in ASCII format. This data can be obtained on floppy disk by contacting the St. Paul District USCOE Hydraulics Section. All of the discharge data collected to date is presented in this report in either tabular or graphical format or both. Discharge measurements obtained by the WDNR is also stored at their office in La Crosse Wisconsin.

Lock and Dam discharge data is stored at the St. Paul District WCC. This data can be obtained by contacting the St. Paul District WCC.

Water Surface Elevations

Water surface elevations collected at gages in the Black River Delta are stored in a manner similar to the discharge measurements and can be obtained by contacting the St. Paul District USCOE Hydraulics Section.

Water surface elevations measured as part of Lock and Dam operation are stored at the St. Paul District WCC. Data for the current year is available on a 4-hour frequency. At the end of each year an average daily value is determined from the 4 hour readings and stored on hard disk. This data can be obtained by contacting the St. Paul District WCC Office.

HYDROLOGY

The Mississippi River at Lock and Dam 6 has a drainage basin area of 60,030 square miles and an average discharge of approximately 33,900 cfs. The main tributary in Pool 7 is the Black River which enters between river miles 708 and 712. The Black River has a total drainage basin area of 2,250 square miles, and an average discharge at Galesville, WI of 1740 cfs. The watershed area at Galesville comprises approximately 92-percent of the total Black River watershed area.

Water discharge and flow patterns in Pool 7 are a function of hydrologic conditions on the Mississippi and Black Rivers. Snowmelt runoff usually causes peak annual discharges on both rivers in the Spring with discharges decreasing throughout the summer until fall when there is often a slight increase in discharge. Spring discharges on the Mississippi and Black Rivers typically exceed 80,000 cfs and 15,000 cfs respectively while a typical summer low discharge is less than 20,000 cfs and 800 cfs respectively. The correlation between Mississippi River discharge at Lock and Dam 6 and Black River discharge

at Galesville is weak (correlation coefficient = 0.483). The physical interpretation of this is that high flows on both rivers may coincide (ie. during spring runoff) but during the summer when the Mississippi River discharges are generally falling off, the Black River is strongly affected by rainfall events which cause numerous flow peaks. In some cases (ie. 1993 flood) the Mississippi River is influenced by summer rainfall events also. Time and length scales for flood events differ greatly between the two rivers - a flood wave may pass through Galesville in a few days while a flood wave on the Mississippi River may take several weeks or months to pass.

Discharge-Duration curves for Lock and Dam 6 and the Black River at Galesville are shown on Figures 3 and 4. The discharge-frequency curve for the Black River at Galesville is shown on Figure 5. The discharges that correspond to the 5, 10, 50, 100, and 500 year floods on the Mississippi River and Black Rivers are given in Table 3.

Table 3. Discharge - Frequency on the Mississippi and Black Rivers.

Time of Return (Years)	Miss. River Discharge at L/D 6 (cfs)	Black River Discharge at Galesville (cfs)
2	88,000	21,500
5	128,000	32,800
10	152,000	40,800
50	216,000	58,000
100	247,000	65,000
500	315,000	82,000

DISCHARGE DISTRIBUTION

Introduction

Site locations where discharge measurements were taken are shown on Figures 1 and 6. Sites are delineated by a number or common name (ie. Dodge Chute) with an arrow pointing to the approximate measurement location. Each measurement location is also given a site location number (used in tables and figures), which identifies the site first by river mile and then by orientation and distance from the navigation channel. The distance and orientation are based on the center of the navigation channel to the center of the site cross sections. As an example, the site location number for Sommers Chute is 706.4NE(1500'), which means Sommers Chute is located 1500 feet northeast of the navigation channel at river mile 706.4

Secondary channel discharge data representing two time periods, 1980-81 and 1991-92, were available for this analysis (Table 4). The 1980-81 data, which is limited to secondary channels along the Mississippi River navigation channel, was collected by the USFWS for a PCB study of Lake Onalaska (Pavlou, et. al. 1982). Data was collected in 1991-92 through a cooperative effort between the WDNR and the USCOE and includes sites along the Mississippi River and in the Black River Delta. Analysis of this data was done to determine existing flow distributions in the Black River/Lake Onalaska area and to determine changes in inflow through secondary channels from the Mississippi River between the 1980-81 and 1991-92 time periods.

Table 4. Summary of Discharge Data Collected in the Black River/Lake Onalaska Area.

Time Period	Discharge Range (cfs)		Secondary Channels Monitored
1980-1981	10,000 to 71,200 on	Miss. River	See Note 1
	500 to 28,300 on	Black River	
1991-1992	15,000 to 78,500 on	Miss. River	See Note 2
	600 to 5,600 on	Black River	

Note: 1. Secondary channels entering the Black River/Lake Onalaska Complex from the Mississippi River navigation channel in the reach between Bullet Chute and Proudfoot Chute along with the North and South Outlets of Lake Onalaska were monitored in 1980-1981. Millers Slough, Wood Slough, and distributary channels in the Black River Delta were not monitored.

2. All secondary channels entering the Black River/Lake Onalaska Complex from the Mississippi River and most of the distributary channels in the Black River delta were monitored.

In the following paragraphs, site discharge is discussed as a percentage of total river discharge (or reference discharge) on the Mississippi or Black Rivers. To facilitate this discussion, the percentages are based reference discharges of 50,000 cfs at Lock and Dam 6 or 2,000 cfs at Galesville unless noted otherwise. These discharges were chosen based on data availability and because they represent typical high flow conditions when a significant amount of mass transport occurs on both rivers. Both discharges are exceeded about 20-percent of the time on an annual basis. For both rivers, flow is still contained within the banks of existing channels which makes quantification of discharge easier. If information for other discharges is desired, the discharge rating curves should be consulted. Since it was desirable to separate Black River impacts from Mississippi River impacts, Lock 6 was used as a reference point instead of Lock 7 (Lock 7 discharges include Black River discharges).

The USGS gaging station at Galesville, Wisconsin provides continuous daily discharge data making it a convenient reference station. However, a couple of factors will cause the instantaneous discharge at Galesville to be different than that in the study area. First, the drainage area at Galesville represents only 92-percent of the total Black River drainage area. Because of this, discharges in the study area will generally be higher than those reported at Galesville. A second factor, is that a flood wave moving down the Black River will have a different instantaneous discharge (higher or lower) at Galesville than in the study area. Additionally, hydrologic storage downstream of Galesville may dampen peak flows associated with a flood wave. While accepted methods exist to transfer discharge from gaged to ungaged points in a watershed and to model flood wave movement, this was beyond the scope of this analysis. Instead, the Galesville data was used without adjustment and each data pair was analyzed to determine if there were potential problems involving the flood wave or storage. The final curve representing Black River site discharge versus Galesville discharge was adjusted based on this analysis.

Mississippi River Secondary Channels

Appendix A contains individual discharge measurements taken at sites along the Mississippi River in Pool 7. The only secondary channel not contained in this data set is Spring Slough near river mile 711.0. Additional discharge data obtained at other sites in Pool 7 is listed at the end of Appendix A. Data for the secondary channels between the Bullet Chute structure and Millers Slough is plotted on Figures 7 through 13. The channels between Millers Slough and the Bullet Chute Structure are inflow channels, while those downstream of Millers Slough (Wood Slough to South Outlet) are outflow channels. Both the 1980-81 and the 1991-92 data is included on Figures 7 through 13.

The 1980-81 data indicates that Sommers Chute, which conveyed 23.2-percent of the total river discharge (percentages based on total Mississippi River discharge of 50,000 cfs), was the largest secondary channel entering Lake Onalaska. The combined discharge through the other channels between Bullet Chute and Proudfoot Slough (not counting Sommers Chute) accounted for 6.5-percent of the total river discharge. In other words, Sommers Chute accounted for 78-percent of the total Mississippi River secondary channel discharge into Lake Onalaska, which is in agreement with Pavlou's interpretation of this data. Millers slough was not monitored in 1980-81, probably because it conveyed a relatively small discharge. The two secondary channels Bullet Chute and No Name Chute accounted for 2.7-percent of the total river discharge. At Bullet, No Name, and Gibbs Chutes, several negative discharge measurements were taken in 1980-81 (ie. the flow was coming out of the backwaters into the navigation channel). This was due to high water events on the Black River coinciding with relatively low discharges on the Mississippi.

For 1991-92 conditions the distribution of inflows is similar to 1980-81 conditions although the amount of inflow increased. Sommers Chute conveyed 26.5-percent of the total river discharge. The combined discharge through the other channels between Bullet Chute and Proudfoot Slough remained similar to the 1980-81 conditions accounting for 6.2-percent of the total river discharge. Millers slough only conveys 0.3-percent of the total river discharge. Discharge at Bullet and No-name Chute now amounts to 2.4-percent of the total river discharge. During the 1980's a significant amount of erosion occurred at these two channels, however, rock lined partial closure structures were constructed here in 1989 as part of the Winters Landing navigation channel project. These structures appear to have restored flow in these secondary channels back to approximately 1980-81 conditions. One negative discharge was measured in 1991-92 at Bullet Chute. Discharges at Gibbs Chute increased since 1980-81; at Goose Chute they remained the same; and at Proudfoot Slough discharges decreased. In the PCB study of Lake Onalaska, it was determined that North Outlet was the major outlet from Lake Onalaska, conveying approximately 72-percent of the total flow in the lake (Pavlou et al. 1982). The one set of discharge measurements at North and South Outlets obtained in 1991-92 indicates that North outlet is still the major outlet conveying 64-percent of the flow in Lake Onalaska. Other outlets included South Outlet, 7.5-percent of the inflow; the Onalaska Spillway, 6-percent; and the French Island Spillway, 1-percent. The unmeasured outflow must occur upstream of North Outlet.

The negative discharges observed at Bullet, No-name, and Gibbs Chutes are examples of the complexity of Black River/Mississippi River flow relationships. Essentially this relationship is defined as: high flow events on the Black River coincident with low flow events on the Mississippi River result in flow reversals in secondary channels upstream of Lake Onalaska - that is, water

enters the navigation channel from the backwaters where usually the opposite is true. This affect is felt all the way up to river mile 711.5 where the direction of flow in Webb Slough, a channel leading to Long Lake, may be reversed.

Figure 14 is a comparison of total inflow to the Lake Onalaska/Black River area from the Mississippi River for 1980-81 and for 1991-92. For 1980-81 conditions, 29.7-percent of the total river discharge entered Lake Onalaska. For 1991-92 conditions, inflows increased to 32.7-percent of the total river discharge, representing a 10-percent increase in Mississippi River discharge to Lake Onalaska. Most of this increase is due to the 15-percent increase at Sommers Chute. For larger flood events the percentage of total river flow conveyed through Lake Onalaska increases. For instance, during the flood of 1993, 52-percent of the total river flow was conveyed through Lake Onalaska. The increased conveyance in Lake Onalaska was due to overtopping of the barrier islands and other landforms which increases conveyance area to the lake.

Lake Onalaska

A significant study of flow distributions within Lake Onalaska was done in the late 1970's and early 1980's. A brief summary of this work follows. Mississippi and Black River water entering Lake Onalaska is distributed throughout the lake depending on hydrologic conditions on the two rivers. Dye studies conducted at the Rivers Studies Center at the University of Wisconsin, La Crosse in the late 1970's indicated that Mississippi River inflows through Sommers Chute tended to follow the west side of the lake, exiting at North Outlet. However, additional dye studies conducted by the United States Geologic Survey (Minnesota District) in April 1978 suggested a tendency for Mississippi River water to move in wider, more easterly trending arcs within the lake as river discharge levels increase above 50,000 cfs (Dexter et al. 1978). Maps delineating spatial and temporal trends in water movement were developed for a PCB study done on Lake Onalaska in the early 1980's. Examination of these maps revealed that all areas of the lake other than Halfway Creek can be classified into three hydrographic zones. These are: predominantly Mississippi River water, predominantly Black River water, and a mixed zone comprised of Mississippi and Black River water (Pavlou, et. al., 1982). The size of these zones varied depending on flow rates on the rivers. During most flow conditions, Mississippi River water dominated the lake, being traced all the way to the Onalaska Spillway. Black River water was usually confined to the eastern side of the lake, much of it being conveyed through the channels on either side of Rosebud Island and then exiting through the Onalaska Spillway. During high flows on the Black River, however, the Black River plume enters the northern end of the lake, and takes a path along the Brice Prairie and Dam 7 shorelines, finally exiting at south outlet. Measurements taken during the winter of 1993 indicate that the flow through the Rosebud Island Channels equaled approximately 1,230 cfs (Sullivan et al. 1993). Flow through the Onalaska Spillway during 1992 and 1993, as measured at Black River Mile 4.8, fluctuated between 1,269 and 1,650 cfs (Hendrickson et al. 1994). The French Lake Aeration Culvert, which will be constructed in 1994, has a maximum discharge of 38 cfs which will have a negligible affect on the flow distribution in Lake Onalaska.

Black River Delta at Bike Trail

The bike trail (formerly Chicago and Northwestern Railroad) provided a convenient reference line to assess the distribution of Black River discharge since all flow must be conveyed through the bike trail bridges. Appendix B

contains the individual discharge measurements taken at each distributary channel of the Black River along the bike trail. Plots of channel discharge versus Black River discharge at Galesville are shown on Figures 15 through 25, with rating curves drawn where appropriate. Only data collected in 1991-92 was available.

Most of the site discharges are fairly well correlated with Black River Discharge, the exceptions being the July 15, 1992 measurements at BR-10 and BR-15 (Tank Creek); and the September 8, 1992 measurements at Dodge-2, Bullet Chute, and Duckhead Chute. Both of these dates correspond to the peak of a flow event passing through Galesville with the recorded discharge at Galesville equaling approximately twice the previous days discharge. For instance, the July 15, 1992 Galesville discharge of 1,950 cfs was preceded by discharges of 858 cfs on July 14 and 709 cfs on July 13; while the September 8, 1992 Galesville discharge of 2,180 cfs was preceded by discharges of 1,280 cfs on September 7 and 892 cfs on September 6. Apparently the flood wave position was such that peak discharges had been reached at Galesville while flow conditions at the bike trail were still rising. Thus the measured discharges on the two dates corresponded to some lower total river discharge. Discharge measurements taken on the hydrograph recession 1 or 2 days after these dates (July 17, 1992 and September 9, 1992) appear to fit the other low flow data fairly well. This is due to the fact that discharges on the flood recession don't change as rapidly as those during the rise.

The April 17 and 18, 1991 high flow measurements also correspond to peak flow events at Galesville, however the discharges on the previous days were relatively high also. For instance the April 17 and 18 discharges of 5,630 and 5,440 cfs respectively were preceded by discharges of 4,840 cfs on April 16 and 3,750 cfs on April 15. However, if curves are extended out to the high flow data points at each site (extrapolation would be required at Bullet and Duckhead Chute) the total discharge obtained by summing the individual discharges at each site is only about 75-percent of that at Galesville. For example, at a total Galesville discharge of 5,000 cfs, the discharge obtained by adding all site discharges is only 3,800 cfs. The bottom line is that while the April 1991 measurements are useful, more data must be obtained to verify conditions at these higher flow rates.

Table 5 summarizes the flow distribution in the vicinity of the bike trail for Black River discharges of 500, 1,000 and 2,000 cfs at Galesville. This summary is based on the discharge curves on Figures 15 through 25 and data contained in Appendix B. Dodge-2, Bullet Chute, Duckhead Chute, Shingle Creek, and Tank Creek, are the major distributary channels in the Black River Delta, while BR-9 and BR-11 through BR-14 didn't convey significant amounts of flow. The summation of distributary channel discharge in Table 5 (last column) is provided as a check on the data analysis. This summation should be equal to or perhaps slightly greater than the reference discharge (first column). The differences shown of 5-percent or less is acceptable.

The main stem of the Black River at Lytles Landing conveys 72-percent of the Black River discharge (based on a total discharge at Galesville of 2,000 cfs). After passing under the bike trail bridges, this flow splits into several different channels with 28-percent of the flow going to Dodge-2, 25-percent to Bullet Chute, and 19-percent to Duckhead Chute. Minimal water is conveyed at the head of Dodge Chute, however, the water conveyed in Dodge-2 enters Dodge Chute 3,000 feet downstream of the head. In other words, it is the upstream 3,000 feet of Dodge Chute that has been affected by sediment deposition. Based on the discharge measurements, stage-discharge data

discussed in the next section, topographic information for the area, and aerial photographs, significant flow through the head of Dodge Chute begins after a Black River discharge of about 2,200 cfs is reached. Shingle Creek as measured at BR-10 conveys at least 9-percent of the Black River discharge. Tank Creek as measured at BR-15 conveys 13-percent of the Black river discharge. On August 5, 1991 and on July 15, 1992 measurements were made at both the bike trail bridge (BR-15) and at a location further upstream, near Highway 93. In both cases, a higher discharge was measured at the upstream location. As discussed at the beginning of this section, the July 15, 1992 measurements are affected by the dynamics of the flood wave moving down the river on that date. However a large wetland between these two sites dampens the flood wave also. In addition, there were inherent measurement errors associated with the highway 93 cross measurements (J. Janvrin, personal communication 1994).

Table 5. Black River Distributary Channel Flow Distribution at Bike Trail.

Black River	Dodge Chute	Dodge 2	Bullet Chute	Duck head Chute	BR9	Shingle Creek BR10	BR11	BR12	BR13	BR14	Tank Creek BR15	Summation
(Discharge, Cubic Feet per Second)												
500	0 (0)	200 (40)	120 (24)	100 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	60 (12)	480 (96)
1000	0 (0)	380 (38)	240 (24)	210 (21)	0 (0)	60 (6)	? (?)	0 (0)	0 (0)	10 (1)	130 (13)	1030 (103)
2000	0 (0)	555 (28)	510 (25)	380 (19)	? (?)	180 (9)	? (?)	? (?)	? (?)	20 (1)	265 (13)	1890 (95)

Note 1. The Summation in the last column was obtained by adding together the individual discharges from each distributary channel. This summation should equal the reference discharge in the first column. The differences shown of 5-percent or less are acceptable.
2. (xx) represents percentage of Black River discharge.
3. ? indicates insufficient data. In all cases these sites represent a relatively small contribution.

Black River Delta Foreset Slope

To supplement the data collected at the bike trail, measurements were obtained at channels further downstream in the Black River delta. Five additional sites, BR-2, BR-4, BR-5, BR-7, and BR-8 have been monitored near the foreset slope of the Black River Delta (Figure 6). These sites were chosen because they represent the downstream end of Dodge Chute, Bullet Chute, Duckhead Chute and Shingle Creek. The foreset slope is the downstream region of primary accretion in reservoir deltas. The foreset could also be thought of as the downstream end of the transition from riverine to reservoir hydrodynamics. In this discussion, it is used to describe the downstream extent of Black River dominated hydrodynamics. Upstream of the foreset slope, stage and channel discharge is dominated by conditions on the Black River while downstream of the foreset slope conditions on the Mississippi River play a greater role.

Data collected at these sites is contained in Appendix B. Figures 26 through 29 are plots of data collected at sites BR-2, BR-4, BR-5, and BR-7. Table 6 summarizes the flow distribution for Black River discharges of 500, 1,000 and 2,000 cfs. Site BR-4 is the largest channel in this area conveying 43-percent of the total flow for a Black River discharge of 2,000 cfs. The combined flow at BR-4 and BR-7 (55-percent) compares well with the combined flow through Dodge-2 and Bullet Chutes (53-percent), as it should. At site BR-2, 26-percent of the Black River flow is conveyed, which is more flow than that entering the head of Duckhead Chute (19-percent). Two possible reasons for this discrepancy include inflow sources that weren't accounted for and limitations with the data. An examination of oblique aerial photographs taken in 1991 and 1992 doesn't support the possibility of additional inflows. There are a couple of tertiary channels connecting Bullet Chute to Duckhead, but it is more likely that water conveyed through these channels contributes to the discharge at site BR-5 rather than flowing to Duckhead Chute. Since the data at the head of Duckhead Chute is limited to 3 points the curve for site BR-2 perhaps is more representative of flow conditions in Duckhead Chute. Flow at site BR-5 amounts to 7-percent of the Black River discharge. The two tertiary channels from Duckhead Chute and Bullet Chute provide flow to this site. Only 1 data point, taken when the Black River discharge was 1,310 cfs, is available at BR-8. Based on this one data point, 4.3-percent of the Black River flow is conveyed at this site. This is less than the 7.6-percent of the flow conveyed at Shingle Creek, as measured at BR-10, for the same total river discharge.

Table 6. Black River Distributary Channel Flow Distribution at Foreset Slope.

Black River	Dodge/Bullet BR4	BR7	Duckhead BR2	Shingle BR8	BR5
	(Discharge, Cubic Feet per Second)				
500 (100)	300 (60)	0 (0)	75 (15)	? (?)	0 (0)
1000 (100)	530 (53)	10 (1)	250 (25)	? (?)	30 (3)
2000 (100)	860 (43)	235 (12)	520 (26)	? (?)	145 (7)

Note 1. (xx) represents percentage of Black River discharge.
2. ? indicates insufficient data. In all cases these sites represent a relatively small contribution.

Black River/Mississippi River/Lake Onalaska Interflow

Since water quality in Lake Onalaska is strongly influenced by the distribution of Black and Mississippi River water, quantification of this distribution is needed. Based on data presented so far, 60-percent of the Black River flows enter directly into Lake Onalaska. Approximately 54-percent of this direct flow comes from Dodge and Bullet Chutes with site BR-5 contributing an additional 7-percent. The remaining 40-percent of the Black River water enters the Mississippi Valley via Tank Creek (13-percent of the total flow) and at Hammond Chute (27-percent of the total flow).

Site BR-3 was monitored to define the distribution of water entering Hammond Chute from sites BR-8 (Shingle Creek) and BR-2 (Duckhead Chute). Generally flow at site BR-3 is in a southeast direction (indicated by positive discharge) when Mississippi River discharge is high, and flow is northwest (negative discharge) when Mississippi River discharge is low. Table 7 summarizes the flow conditions at Hammond Chute on four dates. The flowrates given are based on the raw data in Appendix B with Figure 20 used for missing data at site BR-8 (Shingle Creek).

Table 7. Black River/Mississippi River Interflow at Hammond Chute.

Date	Black River	Lock & Dam 6	Hammond Chute Inflow BR2	BR8	Total (BR2+BR8)	Hammond Chute Outflow to BR3	to Miss. R
	(Discharge, Cubic Feet per Second)						
04/04/91	2780	67400	621	260	881 (100)	425 (48)	456 (52)
09/12/91	885	36800	171	45	216 (100)	79 (36)	137 (64)
09/10/92	1840	28700	544	160	704 (100)	-16 (0)	704 (100)
10/06/92	1310	18000	336	57	393 (100)	-2 (0)	393 (100)

Note 1. (xx) represents percentage of Hammond Chute Inflow.

Based on this data, 0 to 50-percent of the Black River discharge entering Hammond Chute flows directly into the Black River Delta area via BR-3. Since flow through BR-3 hasn't mixed with the Mississippi River, this should be counted as Black River water that enters directly into Lake Onalaska. The remaining Black River flow that enters the Mississippi River first re-enters the Black River delta area at secondary channels such as No Name or Gibbs Chutes and then flows into Lake Onalaska. This hasn't been quantified but aerial photos show a visible plume of Black River water entering the Mississippi River at Hammond Chute and extending downstream along the left bank. Tank Creek water also contributes to this plume, flowing southeasterly across Mud Lake and eventually entering the main channel near Hammond Chute. Table 8 summarizes the distribution of Black River flow to Lake Onalaska.

Table 8. Distribution of Black River Discharge to Lake Onalaska, 1991-92.

Source	Dodge Chute (via Dodge 2)	Bullet Chute	BR-5	Hammond Chute	Tank Creek
Percent of Black River Discharge Conveyed to Lake Onalaska	28	25	7	0 to 14	?

Note 1. Black River reference discharge is 2,000 cfs. Mississippi River discharge varies.

WATER SURFACE ELEVATIONS

Mississippi River

The plan of operation at Lock and Dam 7 is discussed in detail in the Lock and Dam 7 operation manual and is briefly described here. For discharges less than 82,000 cfs, elevation 639 (all elevations given in this report are based on National Geodetic Vertical Datum, 1912 adjustment) is maintained at Lock and Dam 7 and the stages at all other points in the pool vary depending on discharge. At a discharge of 82,000 cfs all the gates at Lock and Dam 7 are raised out of the water, and open river conditions are in effect. On the recession, the gates are returned to the water when the pool at the dam drops to elevation 639.0, which occurs at a discharge of approximately 82,000 cfs. Elevation 639.0 is again maintained at the dam. Figure 30 shows the operation curves for Lock and Dam 7. Table 9 shows stage and slope versus discharge at various locations in Pool 7 based on the operation curves.

Maximum water surface slopes in the lower reach of pool 7 (Lock and Dam 7 to Dakota) occur at a discharge of 80,000 cfs, and then decrease. In upper Pool 7 (Dakota to Lock and Dam 6), the maximum slope is reached at a discharge of 128,000 cfs (5-year flood) and then remains relatively constant. "Upper Mississippi River Water Surface Profiles" (Rock Island District, 1979) gives water surface slopes for the 5 through 100 year floods that are 5 to 10 percent steeper in lower pool 7 and up to 10-percent flatter in upper pool 7. Regardless of the data source used, water surface slopes in upper pool 7 are 1.5 to 3 times higher than those in lower pool 7 for discharges greater than 50,000 cfs. This difference in slope is due mainly to the river planform in Pool 7. At the upstream end of the pool and adjacent the Black River Delta the floodway (ie. the part of the floodplain that effectively conveys water) is relatively narrow. Because of this a greater water surface slope is required to convey water. Once downstream of the Black River delta, however, the floodway widens out (ie. water enters Lake Onalaska) and the water surface slope flattens, since effective conveyance area is greater. The decrease in lower pool slopes at higher discharges corresponds to overtopping of barrier islands and the subsequent increase in backwater conveyance. Slope differences between the upstream and downstream reaches is more pronounced during floods.

Table 9. Pool 7 Water Surface Elevation Versus Discharge.

DISCHARGE At L/D 7	L/D 7 Head Water	Dakota WSEL	L/D 6 Tail Water	Slope L/D 7 to Dakota	Slope Dakota to L/D 6	
RM>>>	702.5	707.23	714.07			
10000	639.00	639.09	639.18	.00000360	.00000249	
15000	639.00	639.16	639.31	.00000641	.00000415	
20000	639.00	639.23	639.48	.00000921	.00000692	
50000	639.00	639.78	641.84	.00003123	.00005704	
60000	639.00	640.02	642.70	.00004084	.00007421	
70000	639.00	640.32	643.50	.00005285	.00008805	
80000	639.00	640.70	644.28	.00006807	.00009913	
90000	639.60	641.15	645.03	.00006206	.00010743	
100000	640.27	641.75	645.75	.00005926	.00011076	
128000	641.92	643.28	647.59	.00005446	.00011934	5 year flood
152000	643.15	644.42	648.82	.00005085	.00012183	10 year flood
170000	644.02	645.22	649.62	.00004805	.00012183	14 year flood of 1993
216000	646.04	647.05	651.32	.00004044	.00011823	50 year flood
247000	647.25	648.18	652.38	.00003724	.00011630	100 year flood

Note: 1. Stages were obtained from the Lock and Dam 7 operation manual.

Changes Due to Lock and Dam Construction

Construction of Lock and Dam 7 resulted in increased stages throughout pool 7 for low flow conditions and decreased stages for higher flow conditions except just upstream of Lock and Dam 7 where there was a small stage increase from the dam. One of the more important aspects of this is that river slope is decreased, even during floods when "open river" conditions are in effect. Water surface elevation changes are summarized in Table 10 for low to intermediate flows. Simons et al. (1976) found that a lowering of bed elevations downstream from each lock and dam due to degradation had contributed to lower flood stages. In addition the submergence of parts of the floodplain by locks and dams operation increases the riverbed area (the flow carrying portion of the river). This results in lower stage for a given discharge during floods when the gates at the locks and dams are opened above the water level and flow conditions approach the natural river conditions (Simons and Chen 1979). The submergence concept can best be thought of as a decrease in floodplain roughness with the changed vegetation communities.

There obviously were impacts on stages, with both increases and decreases, in the lower Black River delta, but the upstream extent of this impact on the Black isn't known. Because of the decreased river slope on the Mississippi River, the potential for delta aggradation may have increased on the downstream side of the delta due to backwater from the Mississippi River while on the upstream side, delta degradation might have increased. The significance of this is the greater potential for Black River migration towards the upstream reaches of pool 7.

Table 10. Discharge Versus Pre and Post Lock and Dam Water Surface Elevations in Pool 7.

	Water Surface Elevation					
	Lock and Dam 7 Headwater		Dakota		Lock and Dam 6 Tailwater	
Discharge (cfs)	Pre Lock and Dam	Post Lock and Dam	Pre Lock and Dam	Post Lock and Dam	Pre Lock and Dam	Post Lock and Dam
20,000	631.40	639.00	633.75	639.25	637.50	639.50
30,000	633.40	639.00	635.85	639.35	639.90	639.90
40,000	635.10	639.00	637.45	639.50	641.35	640.90
50,000	636.45	639.00	638.70	639.70	642.70	641.85
60,000	637.60	639.00	639.90	640.00	643.85	642.60
70,000	638.50	639.00	640.75	640.30	644.85	643.40

Source of Data: Reservoir Regulation Manual, Appendix 7, Lock and Dam No. 7

Black River Delta

Data collected by the Lake Onalaska Protection and Rehabilitation District and the WDNR in 1991-92 was analyzed to determine the relationships between water surface elevations in the Black River Delta and discharge on the Black or Mississippi Rivers. Gage locations are shown on Figure 31. Gages 1, 2, 3, and 4 are located on or near the main stem of the Black River near Lytles. Gages 5

and 6 are located further downstream in the Black River delta. Gages 7 and 8 are located on Shingle and Tank Creek where they intersect the bike trail. A detailed description of gage locations is given in the Appendix. Discharges varying from 14,000 to 97,000 cfs at Lock and Dam 6 and from 400 to 21,000 cfs on the Black River at Galesville occurred during the monitoring period.

Data collected at these gages is contained in Appendix C. Plots of gage water surface elevation versus Black River discharge at Galesville or Mississippi River discharge at Lock and Dam 6 are shown on Figures 32 through 35. Where appropriate stage-discharge curves were drawn. Data points affected by rapid discharge changes due to flood wave propagation between Galesville and the gage were given less emphasis in drawing the curves. Figures 36 and 37 are plots showing gage water surface elevation along with water surface elevations at other points in Pool 7 on the same dates. Gage 2 was knocked over by ice in late fall of 1991 limiting the amount of data available at this gage to that collected in 1992. The correlation between gage water surface elevation and Black or Mississippi River discharge is shown in Table 11. The best correlation between gage elevation and Black River discharge occurs at gages 1 through 4. Gages 5 and 6 show a strong correlation between gage elevation and Mississippi River discharge as would be expected given their proximity to the Mississippi River. The Black River stage/discharge correlation isn't as good at gages 7 and 8, probably due to the fact that these gages are further removed from the Black River main stem and may be influenced by factors such as flood wave movement, bridges, and log jams.

Table 11. Correlation Between Water Surface Elevation and Black or Mississippi River Discharge.

Gage	Black River Stage/Discharge Correlation	Mississippi River Stage/Discharge Correlation
1	0.817	0.639
2	0.914	0.735
3	0.933	0.453
4	0.875	0.645
5	0.707	0.911
6	0.722	0.920
7	0.759	0.563
8	0.746	0.481

A visual comparison of the stage data generally verifies the results in Table 11. Only at gages 5 and 6 does a good relationship exist between Mississippi River discharge and gage elevation. Gage 8 data is correlated well with Mississippi River discharge except during high flow conditions on the Black. These high flows are the reason for the high points at gage 8 and the low correlation with Mississippi River discharge. Intuitively, the strongest relationship between Black River discharge and stage should occur at gages 1, 2, 3, 4, 7, and 8 while the Mississippi River discharge/stage relationship should be strongest at gages 5 and 6. This seems to be verified here. The stage-discharge relationship flattens out considerably for Black River discharges greater than 4,000 or 5,000 cfs on the Black River. Near Dodge Chute (gages 1 and 4) this corresponds to an elevation between 645.0 and 647.0 which is when banks and natural levees are overtopped.

Table 12 summarizes gage water surface elevation for Black River discharges up to 4,000 cfs based on rating curves shown on figures 32 and 33. The corresponding water surface elevation at the Galesville gage (60,550 feet upstream) is also included. There is a significant drop in water surface elevation from gage 1 to gage 5, the head differential being 2.5 feet for low flows and exceeding 5 feet during higher flows on the Black River. There is also a decrease in water surface elevation from gage 1 to gages 7 and 8 on Shingle and Tank Creek of 1.6 feet and 2 feet respectively for low flow conditions and 0.5 feet and 2.5 feet respectively for higher flow conditions. The water surface elevation at gage 5, near the downstream end of Bullet and Dodge Chute, can be higher or lower than that on the Mississippi River at Hammond Chute, which is the downstream end of Duckhead Chute. For low Mississippi River discharges, the water surface at gage 5 is usually slightly higher than that at Hammond Chute, while at high discharges the opposite is true. This partly explains why flow reversals occur at some of the secondary channels in this area.

This water surface elevation data allows qualitative analysis of possible future changes in the Black River. First consider the Black River upstream of the railroad bridges. The channel reaches of interest on the main stem, Shingle Creek and Tank Creeks are defined by the bike trail at the downstream end, and by the upstream junction of the main stem and Shingle or Tank Creeks. Since there is a common water surface elevation on the main stem and either creek at the upstream junction, and given the lower gage readings at gages 7 and 8 than at gage 1, there is obviously a greater head differential on Tank Creek and Shingle Creek than there is on the main stem of the Black River. In addition, channel lengths are 30-percent less along the creek channels than along the main stem for these reaches. So based on a comparison of hydraulic energy slopes, there is a potential for flow increases on both Tank and Shingle Creeks. Without controls, the delta response to this situation would be increased discharge on both creeks and subsequent channel enlargement or formation of new channels. However, this doesn't appear to have happened to any significant degree, probably due to the fixed bridge openings that both Shingle Creek and Tank Creek must pass through. Tank Creek for instance passes through the highway 35 bridge, a small bridge upstream of highway 35, and the two railroad bridges. The railroad bridge openings at sites BR-9 through BR-15 vary in width from 30 feet to 70 feet and in hydraulic mean depth from 1 to 6 feet. In comparison the bridge openings on the main stem at Lytles are much larger, being approximately 200 feet wide and 6 feet deep. The constraints imposed by the bridges will continue to limit changes in flow distribution upstream of the railroad.

Second, consider the Black River delta downstream of the railroad bridges. Changes on Shingle and Tank Creek in this reach are predominantly a function of changes upstream of the railroad which are limited by the fixed openings at the bridges. On the main stem of the Black River, though, changes similar to those observed in the past will continue to occur. Since the water surface slopes along Dodge, Bullet, or Duckhead Chutes are similar (ie. water surface elevations at gage 5 and Hammond Chute are similar), the long term flow distribution in the lower Black River delta will probably continue to be relatively uniform. However, short term flow distributions and channel locations will continue to change significantly.

The last two columns of Table 12 give the water surface slopes between Galesville and gage 1 (reach length = 60,550 feet) and between gage 1 and gage 5 (reach length = 8600 feet). Comparison between these slopes and those given in Table 9 for the Mississippi River indicate significantly greater slopes on

the Black River. For instance, at the 20-percent exceedance discharges on the Black and Mississippi Rivers of 2,000 cfs and 50,000 cfs respectively, the Black River water surface slope is an order of magnitude steeper. It is also noteworthy that the water surface slope between Galesville and gage 1 is flatter than that between gage 1 and gage 5. This doesn't fit the "text book sketches" of gradually decreasing slopes in a downstream direction in deltas.

Table 12. Water Surface Elevations in the Black River Delta.

Black River Discharge Galesville (cfs)	Water Surface Elevation (NGVD, 1912 adj.) Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage Galesville	(Water Slope) Gale. to Gage 1	Gage 1 to Gage 5
500	641.8	641.7	641.7	641.5	639.3	639.2	640.3	640.2	660.92	.000316	.000290
1000	643.1	642.9	642.6	642.5	639.7	639.6	641.4	640.8	661.75	.000308	.000395
2000	644.5	644.1	643.4	643.8	640.2	640.1	643.2	641.8	663.11	.000307	.000500
3000	645.4	644.9	644.0	644.4	640.5	640.4	644.8	642.7	664.23	.000311	.000570
4000	646.1	645.6	644.4	644.9	640.7	640.7	645.6	643.8	665.19	.000315	.000628

CONCLUSIONS

The data presented here provides information on existing and past hydrodynamic conditions in the Black River Delta/Lake Onalaska system. Changes in Mississippi River inflows between the 1980-81 and the 1991-92 time periods have been quantified. Unfortunately, this can't be done for distributaries of the Black River Delta since only 1991-92 discharge data is available. Perhaps one of the most important aspects of this study is that a baseline for future investigations has been established in the Black River Delta. In addition, this data forms a foundation for doing mass transport studies of the system. Specific conclusions that can be drawn include:

a. Discharge through secondary channels between the Mississippi River and the Black River/Lake Onalaska area for the two monitoring periods are given in Table 13. During the 1980-81 monitoring period, inflows from the Mississippi River to Lake Onalaska equaled 29.7-percent of the total Mississippi River discharge. During the 1991-92 monitoring period, inflows increased to 32.7-percent. This represents a 10-percent increase in Mississippi River discharge to Lake Onalaska. Most of this is due to erosion at Sommers Chute which is by far the largest secondary channel entering Lake Onalaska. Although data doesn't exist for post 1993 flood conditions, significant erosion occurred at Sommers Chute during the spring and summer floods, thus existing Mississippi River flows to Lake Onalaska are probably higher than in 1991-92.

b. At Mississippi River discharges greater than 100,000 cfs, many of the barrier islands separating the Black River/Lake Onalaska Area from the navigation channel are overtopped and the percentage of total discharge conveyed through the lake increases. During the summer flood of 1993, USCOE discharge measurements indicate that 52-percent of the total river discharge was conveyed through Lake Onalaska at the peak discharge of 180,000 cfs. This is significantly greater than the total inflows given in Table 13.

Table 13. Discharge Through Secondary Channels Between the Mississippi River and Lake Onalaska for a Total Mississippi River Discharge at Lock and Dam 6 of 50,000 cfs.

Time Period	Bullet Chute	No-name Chute	Gibbs Chute	Goose Chute	Sommers Chute	Proudfoot Chute	Millers Chute	Total Inflow
				(Discharge, Cubic Feet per Second)				
1980-81	560 (1.1)	810 (1.6)	550 (1.1)	395 (0.8)	11600 (23.2)	960 (1.9)	- (-)	14875 (29.7)
1991-92	600 (1.2)	620 (1.2)	695 (1.4)	395 (0.8)	13250 (26.5)	610 (1.2)	171 (0.3)	16341 (32.7)

Note 1. A Lock and Dam 6 discharge of 50,000 cfs is exceeded approximately 20-percent of the time annually.
2. (xx) represents percentage of Mississippi River Discharge.

c. Discharges conveyed through distributary channels of the Black River are given in Table 14. The main stem of the Black River at Lytles conveys 72-percent of the Black River discharge. After passing under the bike trail and railroad bridges, this flow splits into several different channels with 28-percent of the flow going to Dodge-2, 25-percent to Bullet Chute, and 19-percent to Duckhead Chute. Minimal water is conveyed at the head of Dodge Chute for these conditions, however, Dodge-2 enters Dodge Chute 3,000 feet downstream. At discharges greater than 2,200 cfs, stages at the head of Dodge Chute are high enough so that water begins flowing down the chute.

Table 14. Discharge Through Distributary Channels of the Black River at the Bike Trail for a Total Black River Discharge at Galesville of 2,000 cfs.

Time Period	Dodge Chute	Dodge 2	Bul-let Chute	Duck head Chute	BR9	Shingle Creek BR10	BR11	BR12	BR13	BR14	Tank Creek BR15	Summ-ation
						(Discharge, Cubic Feet per Second)						
1991-92	0 (0)	555 (28)	510 (25)	380 (19)	? (?)	180 (9)	? (?)	? (?)	? (?)	20 (1)	265 (13)	1890 (95)

Note 1. A Black River at Galesville discharge of 2,000 cfs is exceeded approximately 20-percent of the time annually.
2. (xx) represents percentage of Black River discharge.
3. ? indicates insufficient data. In all cases these sites represent a relatively small contribution.

d. Based on the 1991-92 data, the percentage of Black River water entering directly into Lake Onalaska varies from 60 to 75-percent depending on hydrologic conditions on the two rivers. The majority of this water is conveyed in Dodge Chute and Bullet Chute (53-percent). Black River flows conveyed through Hammond Chute that re-enter the Black River Delta (with no mixing with the Mississippi River) varied from 0 to 14-percent on survey dates.

Some of the remaining 25 to 40-percent of the Black River flow that enters the Mississippi River first, re-enters the Black River delta area at secondary channels such as No Name or Gibbs Chute and then flows into Lake Onalaska. This hasn't been quantified though.

e. Water surface elevations are highest on the Black River main stem and decrease both in the longitudinal (downstream) and lateral directions. The lateral head differentials potentially could result in the formation of new distributary channels or enlargement of existing channels. However, the railroad and highway bridges some of these distributaries pass through, limit changes in flow distributions upstream of the railroad. Specifically the longterm flow distribution on the main stem, Shingle Creek, and Tank Creek should remain about the same because of the bridge constraints. Support for this conclusion was provided by the 1993 flood. This event corresponded to an 85-year flood, yet little change in Tank Creek was observed. On the main stem downstream of the bike trail bridge, there will continue to be short-term changes in the distribution of flow to Dodge Chute, Dodge-2, Bullet Chute, and Duckhead Chute. Since the head differential and water surface slopes on these chutes are similar, the longterm flow distribution should be relatively uniform.

f. Dodge-2 has replaced the head of Dodge Chute as the primary distributary feeding Lake Onalaska. Unkown is whether the head of Dodge Chute, prior to occlusion, conveyed more or less discharge than Dodge-2 currently does.

Attempting to control the distribution of Black River flow requires more study. One of the primary questions to answer is whether the amount of Black River flow entering Lake Onalaska is changing significantly. Even if a trend is established though, a fix may be difficult due to the dynamic sediment transport regime in the Black River Delta. While a channel could be opened up by dredging, or reduced in size using a rock partial closure structure, these projects could be rendered ineffective after a short number of years due to sediment deposition or new channel formation. However, if there is a beneficial use for delta sand, this should be pursued. The benefits in this case are mainly attributable to using a nearby source of sand, and are not based on the belief that a permanent channel change has been made.

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APPENDIX A

Discharge Measurements taken at Secondary Channels between the Mississippi River and the Black River/Lake Onalaska Area, Pool 7, R.M. 702.5 to 711.8, with additional data in the Navigation Channel and Lake Onalaska.

DATE	SOURCE OF DATA	L&D 7 DISCHARGE (c.f.s.)	L&D 6 DISCHARGE (c.f.s.)	BLACK RIVER DISCHARGE (c.f.s.)	SITE DISCHARGE (c.f.s.)	PERCENT OF L&D 6 DISCHARGE
WEBB SLOUGH, R.M. 711.8 NE 2100'						
7/17/91	USCOE	48850	50797	800	81	0.16%
7/23/91	USCOE	57600	55100	2800	53	0.10%
8/06/91	USCOE	35825	37100	819	43	0.12%
9/12/91	USCOE	38100	36800	885	116	0.32%
7/14/92	USCOE	56300	54900	858	96	0.17%
9/10/92	USCOE	29900	28700	1840	0	0.00%
BULLET CHUTE, R.M. 708.7 NE 2000'						
2/04/80	USFWS	15700	15400	480	261	1.69%
4/16/80	USFWS	74900	71200	3860	1263	1.77%
5/15/80	USFWS	22900	21700	1140	324	1.49%
6/12/80	USFWS	74700	64900	7320	546	0.84%
6/20/80	USFWS	38000	38600	1690	448	1.16%
6/26/80	USFWS	29000	27200	1240	267	0.98%
7/03/80	USFWS	25400	21500	1850	-116	-0.54%
7/10/80	USFWS	16000	14200	908	78	0.55%
7/17/80	USFWS	10900	10400	953	-22	-0.21%
9/03/80	USFWS	31800	23800	4370	-737	-3.10%
9/11/80	USFWS	39400	36600	1930	108	0.30%
9/18/80	USFWS	53000	43800	5500	252	0.58%
9/24/80	USFWS	79100	49800	28300	-1435	-2.88%
10/9/80	USFWS	22800	21800	1740	158	0.72%
10/16/80	USFWS	15900	14000	1650	8	0.06%
10/23/80	USFWS	21700	18200	1890	14	0.08%
3/19/81	USFWS	20500	19300	1430	320	1.66%
4/10/81	USFWS	65800	59400	6090	801	1.35%
4/04/91	USCOE	78500	67407	2780	928	1.38%
4/16/91	USCOE	60125	59903	4840	659	1.10%
8/06/91	USCOE	36100	37100	819	408	1.10%
9/11/91	USCOE	34925	34959	667	415	1.19%
4/15/92	USCOE	49900	47000	2700	550	1.17%
7/14/92	USCOE	56500	54900	858	830	1.51%
9/10/92	USCOE	30200	28700	1840	31	0.11%
10/06/92	USCOE	18775	18000	1310	-185	-1.03%

APPENDIX A (Continued.) Summary of Mississippi River Discharge Measurements.

DATE	SOURCE OF DATA	L&D 7 DISCHARGE (c.f.s.)	L&D 6 DISCHARGE (c.f.s.)	BLACK RIVER DISCHARGE (c.f.s.)	SITE DISCHARGE (c.f.s.)	PERCENT OF L&D 6 DISCHARGE
NO NAME CHUTE, R.M. 708.5 NE 1900'						
2/06/80	USFWS	18300	17200	480	229	1.33%
4/16/80	USFWS	74900	71200	3860	2045	2.87%
5/15/80	USFWS	22900	21700	1140	409	1.88%
6/12/80	USFWS	74700	64900	7320	1229	1.89%
6/20/80	USFWS	38000	38600	1690	588	1.52%
6/26/80	USFWS	29000	27200	1240	299	1.10%
7/03/80	USFWS	25400	21500	1850	88	0.41%
7/10/80	USFWS	16000	14200	908	76	0.54%
7/17/80	USFWS	10900	10400	953	64	0.62%
9/03/80	USFWS	31800	23800	4370	-317	-1.33%
9/11/80	USFWS	39400	36600	1930	210	0.57%
9/18/80	USFWS	53000	43800	5500	353	0.81%
9/24/80	USFWS	79100	49800	28300	596	1.20%
10/9/80	USFWS	22800	21800	1740	141	0.65%
10/16/80	USFWS	15900	14000	1650	130	0.93%
10/23/80	USFWS	21700	18200	1890	77	0.42%
3/19/81	USFWS	20500	19300	1430	348	1.80%
4/10/81	USFWS	65800	59400	6090	1203	2.03%
4/04/91	USCOE	77600	67407	2780	1016	1.51%
4/16/91	USCOE	60475	59903	4840	738	1.23%
8/06/91	USCOE	36100	37100	819	419	1.13%
9/11/91	USCOE	34975	34959	667	310	0.89%
4/15/92	USCOE	49950	47000	2700	574	1.22%
7/14/92	USCOE	56500	54900	858	779	1.42%
9/10/92	USCOE	30000	28700	1840	162	0.56%
10/06/92	USCOE	18850	18000	1310	80	0.44%
GIBBS CHUTE, R.M. 707.6 E 2200'						
2/07/80	USFWS	18000	16800	470	69	0.41%
4/04/80	USFWS	48600	47400	3960	619	1.31%
5/16/80	USFWS	25100	23200	1070	222	0.96%
6/12/80	USFWS	74700	64900	7320	866	1.33%
6/20/80	USFWS	38000	38600	1690	305	0.79%
6/26/80	USFWS	29000	27200	1240	166	0.61%
7/03/80	USFWS	25400	21500	1850	145	0.67%
7/10/80	USFWS	16000	14200	908	77	0.54%
7/17/80	USFWS	10900	10400	953	90	0.87%
8/15/80	USFWS	36700	27300	3190	-106	-0.39%
9/03/80	USFWS	31800	23800	4370	-55	-0.23%
9/11/80	USFWS	39400	36600	1930	183	0.50%
9/18/80	USFWS	53000	43800	5500	379	0.87%
9/24/80	USFWS	79100	49800	28300	665	1.34%
10/09/80	USFWS	22800	21800	1740	64	0.29%
10/16/80	USFWS	15900	14000	1650	108	0.77%
10/23/80	USFWS	21700	18200	1890	92	0.51%
4/10/81	USFWS	65800	59400	6090	873	1.47%
4/02/91	USCOE	86600	77401	3520	1509	1.95%
4/16/91	USCOE	60750	59903	4840	962	1.61%
8/06/91	USCOE	36075	37100	819	254	0.68%
9/11/91	USCOE	35000	34959	667	306	0.88%
4/16/92	USCOE	51400	47100	3360	778	1.65%
7/15/92	USCOE	55800	56500	1950	767	1.36%
10/07/92	USCOE	18950	17600	1250	163	0.93%

APPENDIX A (Continued.) Summary of Mississippi River Discharge Measurements.

DATE	SOURCE OF DATA	L&D 7 DISCHARGE (c.f.s.)	L&D 6 DISCHARGE (c.f.s.)	BLACK RIVER DISCHARGE (c.f.s.)	SITE DISCHARGE (c.f.s.)	PERCENT OF L&D 6 DISCHARGE
		GOOSE CHUTE, R.M. 706.7 NE 1000'				
2/08/80	USFWS	17600	16700	490	0	0.00%
4/16/80	USFWS	74900	71200	3860	1154	1.62%
5/16/80	USFWS	25100	23200	1070	251	1.08%
6/12/80	USFWS	74700	64900	7320	792	1.22%
6/19/80	USFWS	38900	38000	1780	197	0.52%
6/26/80	USFWS	29000	27200	1240	162	0.60%
7/03/80	USFWS	25400	21500	1850	62	0.29%
7/10/80	USFWS	16000	14200	908	86	0.61%
7/17/80	USFWS	10900	10400	953	93	0.89%
8/15/80	USFWS	36700	27300	3190	54	0.20%
9/03/80	USFWS	31800	23800	4370	13	0.05%
9/11/80	USFWS	39400	36600	1930	110	0.30%
9/18/80	USFWS	53000	43800	5500	306	0.70%
9/24/80	USFWS	79100	49800	28300	895	1.80%
10/9/80	USFWS	22800	21800	1740	137	0.63%
10/16/80	USFWS	15900	14000	1650	125	0.89%
10/23/80	USFWS	21700	18200	1890	135	0.74%
3/20/81	USFWS	20500	19300	1380	332	1.72%
4/10/81	USFWS	65800	59400	6090	717	1.21%
6/02/81	USFWS	24700	23900	1110	154	0.64%
4/02/91	USCOE	85800	77401	3520	1159	1.50%
4/15/91	USCOE	61825	62002	3750	710	1.15%
8/06/91	USCOE	36050	37100	819	235	0.63%
9/10/91	USCOE	31150	25100	536	176	0.70%
4/14/92	USCOE	50200	47900	2510	487	1.02%
6/11/92	USCOE	15500	15900	741	91	0.57%
7/15/92	USCOE	55800	56500	1950	402	0.71%
10/07/92	USCOE	18850	17600	1250	106	0.60%

APPENDIX A (Continued.) Summary of Mississippi River Discharge Measurements.

DATE	SOURCE OF DATA	L&D 7 DISCHARGE (c.f.s.)	L&D 6 DISCHARGE (c.f.s.)	BLACK RIVER DISCHARGE (c.f.s.)	SITE DISCHARGE (c.f.s.)	PERCENT OF L&D 6 DISCHARGE
		SOMMERS CHUTE, R.M. 706.4 NE 1500'				
2/14/80	USFWS	15800	15200	490	1552	10.21%
2/22/80	USFWS	16400	15400	520	2495	16.20%
2/26/80	USFWS	19500	18900	480	3311	17.52%
4/01/80	USFWS	49300	48000	3660	10900	22.71%
4/21/80	USFWS	56900	57300	2450	12830	22.39%
5/13/80	USFWS	19200	18300	982	5011	27.38%
5/14/80	USFWS	20600	20400	1400	5223	25.60%
6/04/80	USFWS	35000	28600	3740	5998	20.97%
6/11/80	USFWS	77500	63300	11900	16814	26.56%
6/19/80	USFWS	38900	38000	1780	7702	20.27%
6/25/80	USFWS	29900	27700	1440	5316	19.19%
7/02/80	USFWS	25800	21800	2200	4417	20.26%
7/09/80	USFWS	14100	12600	964	2576	20.44%
7/16/80	USFWS	9500	9400	1150	3118	33.17%
7/31/80	USFWS	11000	10100	606	2137	21.16%
8/14/80	USFWS	43900	33700	5240	5806	17.23%
8/22/80	USFWS	23200	20700	2360	3310	15.99%
9/04/80	USFWS	26500	19700	3280	3720	18.88%
9/10/80	USFWS	42000	38400	1890	6369	16.59%
9/17/80	USFWS	52000	41900	8950	9537	22.76%
9/25/80	USFWS	77100	51400	20700	13803	26.85%
10/8/80	USFWS	22200	20700	1820	4410	21.30%
10/15/80	USFWS	16500	13700	1320	2265	16.53%
10/22/80	USFWS	22500	18900	1760	3239	17.14%
11/22/80	USFWS	22700	20900	1450	3577	17.11%
1/15/81	USFWS	10900	10900	480	1090	10.00%
1/29/81	USFWS	11700	11800	540	1768	14.98%
3/18/81	USFWS	20500	19000	1630	4472	23.54%
4/09/81	USFWS	67700	59200	8620	14823	25.04%
6/01/81	USFWS	27300	26400	1130	3890	14.73%
4/02/91	USCOE	87500	77401	3520	22509	29.08%
6/18/91	USCOE	67125	66703	1040	19213	28.80%
7/23/91	USCOE	58950	55100	2800	16057	29.14%
8/06/91	USCOE	36250	37100	819	8997	24.25%
9/11/91	USCOE	32950	34959	667	8823	25.24%
4/14/92	USCOE	50575	47900	2510	12825	26.77%
6/11/92	USCOE	15400	15900	741	4231	26.61%
7/15/92	USCOE	55800	56500	1950	13656	24.17%
10/07/92	USCOE	18800	17600	1250	4321	24.55%
7/09/93	USCOE	138350	145400	3730	34563	23.77%

APPENDIX A (Continued.) Summary of Mississippi River Discharge Measurements.

DATE	SOURCE OF DATA	L&D 7 DISCHARGE (c.f.s.)	L&D 6 DISCHARGE (c.f.s.)	BLACK RIVER DISCHARGE (c.f.s.)	SITE DISCHARGE (c.f.s.)	PERCENT OF L&D 6 DISCHARGE
PROUDFOOT SLOUGH, R.M. 705.7 NE 2600'						
2/19/80	USFWS	16100	15500	470	154	0.99%
4/04/80	USFWS	48600	47400	3960	964	2.03%
5/16/80	USFWS	25100	23200	1070	421	1.81%
6/04/80	USFWS	35000	28600	3740	542	1.90%
6/11/80	USFWS	77500	63300	11900	1536	2.43%
6/19/80	USFWS	38900	38000	1780	570	1.50%
6/25/80	USFWS	29900	27700	1440	378	1.36%
7/02/80	USFWS	25800	21800	2200	351	1.61%
7/09/80	USFWS	14100	12600	964	213	1.69%
7/17/80	USFWS	10900	10400	953	135	1.30%
7/31/80	USFWS	11000	10100	606	139	1.38%
8/14/80	USFWS	43900	33700	5240	465	1.38%
8/22/80	USFWS	23200	20700	2360	193	0.93%
9/04/80	USFWS	26500	19700	3280	357	1.81%
9/10/80	USFWS	42000	38400	1890	554	1.44%
9/17/80	USFWS	52000	41900	8950	879	2.10%
10/9/80	USFWS	22800	21800	1740	331	1.52%
10/16/80	USFWS	15900	14000	1650	232	1.66%
10/23/80	USFWS	21700	18200	1890	258	1.42%
1/14/81	USFWS	10800	10900	480	71	0.65%
3/18/81	USFWS	20500	19000	1630	376	1.98%
4/09/81	USFWS	67700	59200	8620	1229	2.08%
6/01/81	USFWS	27300	26400	1130	334	1.27%
4/01/91	USCOE	83200	78600	4470	1558	1.98%
4/15/91	USCOE	61900	62002	3750	1011	1.63%
8/06/91	USCOE	36025	37100	819	403	1.09%
9/10/91	USCOE	31250	25100	536	337	1.34%
4/14/92	USCOE	50200	47900	2510	569	1.19%
6/11/92	USCOE	15600	15900	741	187	1.18%
7/15/92	USCOE	56100	56500	1950	701	1.24%
10/07/92	USCOE	18900	17600	1250	153	0.87%
MILLERS SLOUGH, R.M. 704.7 NE 3900'						
4/15/91	USCOE	62150	62002	3750	424	0.68%
8/05/91	USCOE	36150	36500	775	85	0.23%
9/10/91	USCOE	31275	25100	536	72	0.29%
4/14/92	USCOE	50250	47900	2510	203	0.42%
6/11/92	USCOE	15600	15900	741	38	0.24%
7/15/92	USCOE	56000	56500	1950	158	0.28%
10/07/92	USCOE	18925	17600	1250	45	0.26%

APPENDIX A (Continued.) Summary of Mississippi River Discharge Measurements.

DATE	SOURCE OF DATA	L&D 7 DISCHARGE (c.f.s.)	L&D 6 DISCHARGE (c.f.s.)	BLACK RIVER DISCHARGE (c.f.s.)	SITE DISCHARGE (c.f.s.)	PERCENT OF L&D 7 DISCHARGE
NORTH OUTLET, R.M. 702.8 NE 1800'						
2/20/80	USFWS	16200	15500	500	1241	7.66%
4/02/80	USFWS	46800	43400	4150	11892	25.41%
4/23/80	USFWS	51000	50400	2410	13995	27.44%
5/14/80	USFWS	20600	20400	1400	3640	17.67%
6/04/80	USFWS	35000	28600	3740	6394	18.27%
6/11/80	USFWS	77500	63300	11900	18254	23.55%
6/18/80	USFWS	41200	39100	1910	8243	20.01%
6/25/80	USFWS	29900	27700	1440	5738	19.19%
7/02/80	USFWS	25800	21800	2200	4462	17.29%
7/09/80	USFWS	14100	12600	964	2211	15.68%
7/16/80	USFWS	9500	9400	1150	3105	32.68%
7/31/80	USFWS	11000	10100	606	1833	16.66%
8/14/80	USFWS	43900	33700	5240	7386	16.82%
8/21/80	USFWS	20900	18400	1860	5049	24.16%
9/04/80	USFWS	26500	19700	3280	4549	17.17%
9/10/80	USFWS	42000	38400	1890	9964	23.72%
9/17/80	USFWS	52000	41900	8950	12411	23.87%
9/25/80	USFWS	77100	51400	20700	18162	23.56%
10/8/80	USFWS	22200	20700	1820	4107	18.50%
10/15/80	USFWS	16500	13700	1320	2516	15.25%
10/22/80	USFWS	22500	18900	1760	3600	16.00%
11/25/80	USFWS	22100	20400	1380	3549	16.06%
1/30/81	USFWS	11600	11700	520	1248	10.76%
3/18/81	USFWS	20500	19000	1630	8647	42.18%
4/09/81	USFWS	67700	59200	8620	17792	26.28%
6/01/81	USFWS	27300	26400	1130	3662	13.41%
4/18/91	USCOE	63750	63691	5440	16416	25.75%
SOUTH OUTLET, R.M. 702.7 NE 1700'						
2/21/80	USFWS	16100	15500	500	36	0.22%
4/02/80	USFWS	46800	43400	4150	503	1.07%
6/04/80	USFWS	35000	28600	3740	299	0.85%
6/11/80	USFWS	77500	63300	11900	1052	1.36%
6/18/80	USFWS	41200	39100	1910	311	0.75%
6/25/80	USFWS	29900	27700	1440	104	0.35%
7/02/80	USFWS	25800	21800	2200	103	0.40%
7/09/80	USFWS	14100	12600	964	42	0.30%
7/16/80	USFWS	9500	9400	1150	4	0.04%
7/31/80	USFWS	11000	10100	606	18	0.16%
8/14/80	USFWS	43900	33700	5240	71	0.16%
8/21/80	USFWS	20900	18400	1860	37	0.18%
9/04/80	USFWS	26500	19700	3280	26	0.10%
9/10/80	USFWS	42000	38400	1890	78	0.19%
9/17/80	USFWS	52000	41900	8950	204	0.39%
10/08/80	USFWS	22200	20700	1820	55	0.25%
10/15/80	USFWS	16500	13700	1320	8	0.05%
10/22/80	USFWS	22500	18900	1760	6	0.03%
4/09/81	USFWS	67700	59200	8620	1058	1.56%
6/01/81	USFWS	27300	26400	1130	180	0.66%
4/18/91	USCOE	63800	63691	5440	1921	3.01%

APPENDIX A (Continued.) Summary of Mississippi River Discharge Measurements.

DATE	SOURCE OF DATA	L&D 7 DISCHARGE (c.f.s.)	L&D 6 DISCHARGE (c.f.s.)	BLACK RIVER DISCHARGE (c.f.s.)	SITE DISCHARGE (c.f.s.)	PERCENT OF L&D 6 DISCHARGE
NAVIGATION CHANNEL, R.M. 709.0						
8/28/86	USCOE	45500	47600	978	45975	96.59%
NAVIGATION CHANNEL, R.M. 708.8						
10/06/93	USCOE	34500	35100		30722	87.53%
NAVIGATION CHANNEL, R.M. 708.3						
7/23/91	USCOE	58300	55100	2800	50876	92.33%
8/08/91	USCOE	40550	38398	1220	37156	96.77%
NAVIGATION CHANNEL, R.M. 706.5						
4/03/91	USCOE	83850	74203	3190	57274	77.19%
4/17/91	USCOE	60600	60000	5630	45233	75.39%
8/07/91	USCOE	35525	36700	937	25655	69.90%
9/12/91	USCOE	42575	36800	885	31672	86.07%
4/15/92	USCOE	50000	47000	2700	40184	85.50%
7/15/92	USCOE	55500	56500	1950	46666	82.59%
WEST SIDE OF DAKOTA ISLAND, R.M. 706.5 SW 1300'						
4/03/91	USCOE	85350	74203	3190	11399	15.36%
4/17/91	USCOE	60600	60000	5630	7683	12.81%
8/07/91	USCOE	35560	36700	937	4652	12.68%
9/11/91	USCOE	35050	34959	667	4386	12.55%
7/15/92	USCOE	55600	56500	1950	7879	13.95%
EAST SIDE OF ISLAND, R.M. 707.3 NE 1200'						
4/18/91	USCOE	63700	63691	5440	13589	21.34%
8/07/91	USCOE	35600	36700	937	7501	20.44%
9/12/91	USCOE	42450	36800	885	8819	23.96%

APPENDIX A (Continued.) Summary of Mississippi River Discharge Measurements.

DATE	SOURCE OF DATA	L&D 7 DISCHARGE (c.f.s.)	L&D 6 DISCHARGE (c.f.s.)	BLACK RIVER DISCHARGE (c.f.s.)	SITE DISCHARGE (c.f.s.)	PERCENT OF L&D 7 DISCHARGE
BRICE PRAIRIE TO BROKEN GUN ISLAND R.M. 704.0 NE 17000'						
6/25/93	USCOE	179650	183800	14900	18670	10.39%
BROKEN GUN ISLAND TO CORMORANT ISLAND R.M. 704.0 NE 13000'						
6/25/93	USCOE	178000	183800	14900	40256	22.62%
CORMORANT ISLAND TO WEST SHORELINE R.M. 704.0 NE 8000'						
6/25/93	USCOE	179100	183800	14900	34867	19.47%
ROSEBUD ISLAND TO BELL ISLAND R.M. 703.0 NE 17000'						
11/11/87	WDNR	18300	17300	1050	1080	5.90%
4/13/92	USCOE	51800	48800	2600	-632	-1.22%
1/11/93	WDNR	19300	18700		836	4.33%
2/05/93	WDNR	18300	17800		859	4.69%
ROSEBUD ISLAND TO NEXT ISLAND NORTH R.M. 703.7 NE 17000'						
12/06/89	WDNR	10900	8300	520	314	2.88%
2/08/90	WDNR	9800	7000	440	193	1.97%
4/13/92	USCOE	51800	48800	2600	819	1.58%
1/11/93	WDNR	19300	18700		272	1.41%
2/05/93	WDNR	18300	17800		215	1.17%
FWS BOATLANDING TO ISLAND NORTH OF ROSEBUD R.M. 703.8 NE 17000'						
12/06/89	WDNR	10900	8300	520	60	0.55%
2/08/90	WDNR	9800	7000	440	145	1.48%
4/13/92	USCOE	51800	48800	2600	-87	-0.17%
1/11/93	WDNR	19300	18700		122	0.63%
2/05/93	WDNR	18300	17800		157	0.86%

Note:1 Fish & Wildlife Service data obtained for the Upper Mississippi River P.C.B. Project.
Note:2 Corps of Engineers data obtained for the Dodge Chute Study and the Dakota Navigation Channel Study.
Note:3 Black River flows for the 1980 through 1992 water years are the mean daily discharges at the U.S.G.S. gage near Galesville, Wisconsin.
Note:4 Black River flows for the 1993 water year are the Galesville provisinal mean daily discharges sent from the U.S.G.S., (Wisconsin Office).
Note:5 Lock and Dam 6 discharge is the 08:00 reading for that day.
Note:6 Lock and Dam 7 discharge is the 08:00 reading for that day for the 1980 through 1987 data.
Note:7 Lock and Dam 7 discharge is interpolated from the four hour readings for that day for the 1991 through 1993 data.

APPENDIX B

Discharge Measurements taken at Distributary Channels in the Black River Delta Area of Pool 7, R.M. 708.7 to 711.8

DATE	SOURCE OF DATA	L&D 7 Q	L&D 6 Q	BLACK RIVER Q	SITE Q	PERCENT OF BLACK RIVER Q
			Dodge Chute			
4/18/91	WDNR	61400	63691	5440	265	4.87%
7/10/91	WDNR	60100	60600	654	0	0.00%
8/08/91	WDNR	39500	38398	1220	0	0.00%
1/31/92	WDNR	24100	23100	900	0	0.00%
7/17/92	WDNR	56500	56600	1210	0	0.00%
9/08/92	WDNR	28700	26800	2180	0	0.00%
10/07/92	WDNR	18800	17600	1250	0	0.00%
			Dodge 2			
4/18/91	WDNR	61400	63691	5440	845	15.53%
7/10/91	WDNR	60100	60600	654	273	41.74%
8/08/91	WDNR	39500	38398	1220	446	36.56%
1/31/92	WDNR	24100	23100	900	338	37.56%
7/17/92	WDNR	56500	56600	1210	419	34.63%
9/08/92	WDNR	28700	26800	2180	430	19.72%
10/07/92	WDNR	18800	17600	1250	428	34.24%
			Bullet Chute			
7/17/92	WDNR	56500	56600	1210	314	25.95%
9/08/92	WDNR	29025	26800	2180	400	18.35%
10/07/92	WDNR	18800	17600	1250	286	22.88%
			Duck Head			
7/17/92	WDNR	56500	56600	1210	232	19.17%
9/08/92	WDNR	29675	26800	2180	265	12.16%
10/07/92	WDNR	18800	17600	1250	258	20.64%
			Main Stem of Black River 500' D/S Hwy 93			
4/05/91	USCOE	72100	68089	2550	1821	71.41%
			Site "BR-1A" R.M. 708.7 NE 2300'			
4/16/91	USCOE	61000	59903	4840	1125	23.24%
4/15/92	USCOE	49925	47000	2700	857	31.74%
7/14/92	USCOE	56500	54900	858	1104	128.67%
9/10/92	USCOE	30100	28700	1840	126	6.85%

APPENDIX B (Continued.) Discharge Measurements taken at Distributary Channels in the the Black River Delta Area of Pool 7, R.M. 708.7 to 711.8

SITE	DATE	SOURCE OF DATA	L&D 7 Q	L&D 6 Q	BLACK RIVER Q	SITE Q	PERCENT OF BLACK RIVER Q
Site "BR-1B" R.M. 708.8 NE 2800'							
	4/16/91	USCOE	60100	59903	4840	124	2.56%
	4/15/92	USCOE	49900	47000	2700	83	3.07%
	9/10/92	USCOE	29900	28700	1840	0	0.00%
Site "BR2"							
	4/04/91	USCOE	77450	67407	2780	621	22.34%
	4/16/91	USCOE	60100	59903	4840	1030	21.28%
	8/07/91	USCOE	35875	36700	937	181	19.32%
	9/12/91	USCOE	39850	36800	885	171	19.32%
	4/15/92	USCOE	49900	47000	2700	659	24.41%
	7/14/92	USCOE	56500	54900	858	206	24.01%
	9/10/92	USCOE	29900	28700	1840	544	29.57%
	10/06/92	USCOE	19450	18000	1310	336	25.65%
Site "BR3"							
	4/04/91	USCOE	77400	67407	2780	425	15.29%
	9/12/91	USCOE	41225	36800	885	79	8.93%
	9/10/92	USCOE	29900	28700	1840	-16	-0.87%
	10/06/92	USCOE	19100	18000	1310	-2	-0.15%
Site "BR4"							
	4/04/91	USCOE	77550	67407	2780	991	35.65%
	4/16/91	USCOE	60150	59903	4840	1240	25.62%
	8/07/91	USCOE	35575	36700	937	436	46.53%
	9/12/91	USCOE	42600	36800	885	474	53.56%
	4/15/92	USCOE	49900	47000	2700	935	34.63%
	7/14/92	USCOE	56500	54900	858	492	57.34%
	9/10/92	USCOE	29900	28700	1840	858	46.63%
	10/06/92	USCOE	18900	18000	1310	602	45.95%
Site "BR5"							
	9/12/91	USCOE	40400	36800	885	28	3.16%
Site "BR6"							
	8/07/91	USCOE	36400	36700	937	88	9.39%
	9/10/92	USCOE	29900	28700	1840	114	6.20%
	10/06/92	USCOE	19000	18000	1310	46	3.51%

APPENDIX B (Continued.) Discharge Measurements taken at Distributary Channels in the the Black River Delta Area of Pool 7, R.M. 708.7 to 711.8

SITE	DATE	SOURCE OF DATA	L&D 7 Q	L&D 6 Q	BLACK RIVER Q	SITE Q	PERCENT OF BLACK RIVER Q
Site "BR7"							
	9/10/92	USCOE	29900	28700	1840	199	10.82%
	10/06/92	USCOE	18850	18000	1310	79	6.03%
Site "BR8"							
	10/06/92	USCOE	19450	18000	1310	57	4.35%
Site "BR9"							
	4/17/91	WDNR	60000	60000	5630	85	1.51%
	7/09/91	WDNR	60100	61000	689	0	0.00%
	8/05/91	WDNR	35900	36500	775	0	0.00%
	1/30/92	WDNR	24600	23000	900	0	0.00%
	7/17/92	WDNR	56500	56600	1210	0	0.00%
	9/08/92	WDNR	28700	26800	2180	0	0.00%
	10/07/92	WDNR	18800	17600	1250	0	0.00%
Site "BR10" (Shingle Creek)							
	4/17/91	WDNR	60000	60000	5630	595	10.57%
	7/09/91	WDNR	60100	61000	689	35	5.08%
	8/05/91	WDNR	35900	36500	775	30	3.87%
	1/30/92	WDNR	24600	23000	900	41	4.56%
	7/15/92	WDNR	55800	56500	1950	120	6.15%
	9/09/92	WDNR	30800	28600	1980	170	8.59%
	10/05/92	WDNR	19950	17500	1350	92	6.81%
Site "BR11"							
	4/17/91	WDNR	60000	60000	5630	432	7.67%
	7/09/91	WDNR	60100	61000	689	0	0.00%
	8/05/91	WDNR	35900	36500	775	0	0.00%
	1/30/92	WDNR	24600	23000	900	15	1.67%
	7/17/92	WDNR	56500	56600	1210	0	0.00%
	9/08/92	WDNR	28700	26800	2180	0	0.00%
	10/07/92	WDNR	18800	17600	1250	0	0.00%

APPENDIX B (Continued.) Discharge Measurements taken at Distributary Channels in the the Black River Delta Area of Pool 7, R.M. 708.7 to 711.8

SITE	DATE	SOURCE OF DATA	L&D 7 Q	L&D 6 Q	BLACK RIVER Q	SITE Q	PERCENT OF BLACK RIVER Q
Site "BR12"							
	4/17/91	WDNR	60000	60000	5630	96	1.71%
	7/09/91	WDNR	60100	61000	689	0	0.00%
	8/05/91	WDNR	35900	36500	775	0	0.00%
	1/30/92	WDNR	24600	23000	900	2	0.22%
	7/17/92	WDNR	56500	56600	1210	0	0.00%
	9/08/92	WDNR	28700	26800	2180	0	0.00%
	10/07/92	WDNR	18800	17600	1250	0	0.00%
Site "BR13"							
	1/30/92	WDNR	24600	23000	900	0	0.00%
	7/17/92	WDNR	56500	56600	1210	0	0.00%
	9/08/92	WDNR	28700	26800	2180	0	0.00%
	10/07/92	WDNR	18800	17600	1250	0	0.00%
Site "BR14"							
	4/17/91	WDNR	60000	60000	5630	87	1.55%
	7/09/91	WDNR	60100	61000	689	9	1.31%
	8/05/91	WDNR	35900	36500	775	3	0.39%
	1/30/92	WDNR	24600	23000	900	13	1.44%
	7/17/92	WDNR	56500	56600	1210	0	0.00%
	9/08/92	WDNR	28700	26800	2180	0	0.00%
	10/05/92	WDNR	19950	17500	1350	10	0.74%
Site "BR15" (Tank Creek)							
	4/17/91	WDNR	60000	60000	5630	414	7.35%
	7/09/91	WDNR	60100	61000	689	100	14.51%
	8/05/91	WDNR	35900	36500	775	73	9.42%
	1/30/92	WDNR	24600	23000	900	131	14.56%
	7/15/92	WDNR	55900	56500	1950	113	5.79%
	9/09/92	WDNR	30000	28600	1980	261	13.18%
	10/05/92	WDNR	19950	17500	1350	167	12.37%
Tank Creek (Hwy. 93)							
	8/05/91	WDNR	35900	36500	775	95	12.26%
	7/15/92	WDNR	56050	56500	1950	202	10.36%

Note: 1 Wisconsin Department of Natural Resources data obtained for the Dodge Chute Study.
2 Corps of Engineers data obtained for the Dodge Chute Study and the Dakota Navigation Channel Study.
3 Black River flows for the 1991 & 1992 water years are the mean daily discharges at the U.S.G.S. gage near Galesville, Wisconsin.
4 Black River flows for the 1993 water year are the Galesville provisional mean daily discharges sent from the U.S.G.S., (Wisconsin Office).
5 Lock and Dam 6 discharge is the 08:00 reading for that day.
6 Lock and Dam 7 discharge is interpolated from the four hour readings for that day.

APPENDIX C

Black River Delta Water Surface Elevation Versus Discharge Data.

	BLACK RIVER DISCHARGE	L&D 7 DISCHARGE	L&D 6 DISCHARGE	L&D 7 POOL	L&D 7 CONTROL POINT	L&D 6 TAIL-WATER	GAUGE#1 WATER SURFACE	GAUGE#2 WATER SURFACE	GAUGE#3 WATER SURFACE	GAUGE#4 WATER SURFACE	GAUGE#5 WATER SURFACE	GAUGE#6 WATER SURFACE	GAUGE#7 WATER SURFACE	GAUGE#8 WATER SURFACE
18-JUL-1991	900	50588	53102	639.22	640.04	641.97	642.84			642.28	639.51			
23-JUL-1991	2800	58900	55100	639.29	640.22	642.31	644.69			644.18	640.41	640.22		
24-JUL-1991	1900	51000	52400	639.11	640.01	641.98	644.29		643.46				643.13	641.48
26-JUL-1991	1200	46800	46801	638.98	639.73	641.50	643.44		642.71	643.07	639.88	639.77	641.86	641.01
27-JUL-1991	1100	42000	42299	638.83	639.53	641.15							641.58	640.74
28-JUL-1991	1100	41100	41700	638.94	639.58	641.08	642.79							
30-JUL-1991	931	38500	38600	639.02	639.53	640.89	642.74		642.64	642.42	639.58	639.53	641.21	640.61
02-AUG-1991	812	35500	34853	639.08	639.50	640.62	642.44			642.18	639.51	639.49		
03-AUG-1991	776	35800	35000	639.14	639.49	640.64							640.93	640.54
04-AUG-1991	784	36300	35200	639.11	639.47	640.61	642.41		642.25	642.13	639.47	639.47		
05-AUG-1991	775	35900	36500	639.05	639.46	640.59							640.86	641.44
07-AUG-1991	937	36100	36700	639.01	639.46	640.59					639.51	639.42		
08-AUG-1991	1220	39600	38398	639.23	639.71	640.83	643.09							
10-AUG-1991	1120	40800	38900	639.19	639.64	640.91	643.14			642.78	639.74	639.63		
11-AUG-1991	1020	40300	38900	639.10	639.58	640.85	642.94			642.63	639.71	639.58		
13-AUG-1991	918	37900	36000	638.91	639.38	640.58							641.18	640.64
15-AUG-1991	759	35900	36100	638.92	639.39	640.53	642.31			642.04	639.41	639.42		
17-AUG-1991	693	40000	39400	639.19	639.63	640.90	642.34			642.09	639.61			
20-AUG-1991	617	34600	33700	639.00	639.37	640.43				641.88	639.36			
25-AUG-1991	573	29300	29200	639.04	639.31	640.16							640.53	640.44
31-AUG-1991	483	22300	21600	639.20	639.32	639.87					639.31	639.29		
02-SEP-1991	443	18300	19200	639.18	639.26	639.85							640.38	640.29
10-SEP-1991	536	31200	25100	639.18	639.33	639.99							641.53	640.69
11-SEP-1991	667	35100	34959	638.95	639.22	640.06						639.25		
12-SEP-1991	885	42600	36800	639.06	639.52	640.56					639.51			
14-SEP-1991	1080	51500	48300	638.99	639.77	641.40	642.99						642.48	641.14
15-SEP-1991	1140	55300	51100	639.21	640.00	641.81	643.21			642.85	640.01	640.02		
18-SEP-1991	2290	60800	53999	639.10	640.07	642.13	644.66			644.19	640.41	640.22		
30-SEP-1991	641	37300	39700	638.99	639.52	640.92							640.78	640.69
05-OCT-1991	614	33088	32998	639.10	639.41	640.40							640.93	640.49
14-OCT-1991	609	24500	23700	639.11	639.31	639.99							640.83	640.29
20-OCT-1991	597	23700	24602	639.23	639.53	640.17							641.18	640.49
27-OCT-1991	1130	22300	21000	639.06	639.22	639.81							641.53	640.49
30-OCT-1991	1330	24000	21500	639.27	639.29	639.82	643.54			643.12	639.71	639.27	641.88	640.54
02-NOV-1991	2990	32100	31100	639.35	639.60	640.46	645.09							
05-NOV-1991	12000	54100	47800	639.29	640.12	641.74	646.79		647.75	645.58				
06-NOV-1991	7400	68314	52100	639.46	640.43	642.26	647.07		645.65	645.98	640.26	640.77		
07-NOV-1991	3800	64800	54000	639.38	640.64	642.57							646.73	644.09
11-NOV-1991	1620	38000	37059	638.98	639.62	640.90	644.79							
14-NOV-1991	1400	33900	32800	638.96	639.34	640.48	643.74	643.71	642.80	643.18			641.98	640.67
16-NOV-1991	2270	40800	38900	639.16	639.62	640.96	644.19							
18-NOV-1991	4240	45600	43000	639.22	639.85	641.27	645.59						641.58	644.64
19-NOV-1991	4570	49200	44100	639.18	639.83	641.39	645.79		644.65				641.53	644.69
20-NOV-1991	8020	50900	47100	639.13	639.89	641.59	645.99							
21-NOV-1991	11100	54701	52100	639.21	640.22	642.07	646.59							
22-NOV-1991	8160	69800	62202	639.38	640.58	642.83	646.79		645.35	645.63	641.06	640.92		
21-DEC-1991	2000	38500	36700	639.06	640.54	642.63			644.65					

Note:1 Black River staff gages set in the summer of 1991.
Note:2 Gage "0"'s for 1991 and January 1992 are as surveyed 17 February 1992 through 27 February 1992.
Note:3 Gage "0"'s resurveyed November 1992.
Note:4 1992 Gage water surface elevations were computed by the W.D.N.R.
Note:5 Black River flows for the 1991 & 1992 water years are the daily mean discharge at the U.S.G.S. gage near Galesville, Wisconsin.
Note:6 Black River flows for the 1993 water year is the provisional daily mean discharge at the U.S.G.S. gage near Galesville, Wisconsin.
Note:7 Gage #5 has been discontinued as of 8 May 1992 due to the loss of the tree that the gage was attached.
Note:8 Gage #2 data prior to 14 November 1991 has been lost due to ice before the gage was tied into a T.B.M.

APPENDIX C

(Continued.) Black River Delta Water Surface Elevation Versus Discharge Data.

	BLACK RIVER DISCHARGE	L&D 7 DISCHARGE	L&D 6 DISCHARGE	L&D 7 POOL	L&D 7 CONTROL POINT	L&D 6 TAIL-WATER	GAUGE#1 WATER SURFACE	GAUGE#2 WATER SURFACE	GAUGE#3 WATER SURFACE	GAUGE#4 WATER SURFACE	GAUGE#5 WATER SURFACE	GAUGE#6 WATER SURFACE	GAUGE#7 WATER SURFACE	GAUGE#8 WATER SURFACE
01-JAN-1992	1600	33100	33900	638.98		641.71	644.59							
30-JAN-1992	900	24600	23000	639.01	639.57	640.72							641.58	640.84
31-JAN-1992	900	24100	23100	639.08	639.54	640.74				642.93				
24-MAR-1992	2520	74600	70300	638.92	640.50	643.48	644.59							
28-MAR-1992	5160	69600	64950	639.05	640.39	643.07	646.79							
29-MAR-1992	4580	70700	65100	639.18	640.48	643.11	646.99							
03-APR-1992	4160	66100	60100	639.00	640.24	642.70	646.79							
06-APR-1992	3090	59700	54500	638.93	640.07	642.35	646.79							
14-APR-1992	2510	51600	47900	638.86	639.70	641.73	645.19		644.05					
20-APR-1992	8310	68200	59850	639.39	640.46	642.78	647.89	646.49						
23-APR-1992	10500	70800	67100	639.13	640.53	643.29							645.68	643.14
26-APR-1992	4730	90353	97100	639.54	641.39	645.05	646.79	645.69	645.60	645.15	641.56	641.60		
28-APR-1992	2870	89700	94000	639.07	641.17	644.86	645.89	644.94		644.35	641.26	641.27		
29-APR-1992	2380	88500	90200	638.77	641.00	644.63							644.03	642.14
05-MAY-1992	1610	70200	67350	638.79	640.25	643.30							642.53	641.84
08-MAY-1992	1360	58700	59400	638.80	639.88	642.09	644.14	643.30		642.90	640.26	639.99		
11-MAY-1992	1190	47000	44000	638.80	639.50	641.01							641.73	
19-MAY-1992	6140	39700	38200	639.11	639.59	640.65	645.22	645.08	644.60	644.50		639.80		
21-MAY-1992	2830	43000	38100	639.16	639.64	640.70	645.09							
22-MAY-1992	2130	42300	38200	639.05	639.50	640.64							642.73	641.19
30-MAY-1992	1180	31100	29800	639.09	639.35	640.03	643.19							
10-JUN-1992	753	14900	14300	638.64	638.72	638.95							640.73	640.49
11-JUN-1992	741	13100	15900	638.90	639.00	639.17	642.41	641.59		641.95		639.20		
17-JUN-1992	791	15700	15900	639.18	639.25	639.47	642.59			642.15		639.55		
19-JUN-1992	865	27500	26501	639.29	639.44	639.93	642.75	642.64		642.27		639.57	641.13	640.69
26-JUN-1992	732	37300	37400	639.10	639.43	640.34							640.53	640.49
01-JUL-1992	653	36800	36500	639.05	639.44	640.41							640.53	640.49
11-JUL-1992	645	50300	53000	639.27	639.98	641.65			643.95					
15-JUL-1992	1950	55900	56500	639.08	640.03	641.92							640.93	640.74
21-JUL-1992	837	46100	46900	638.81	639.70	641.12	642.59	642.59	642.55					
24-JUL-1992	1150	43200	43900	639.09	639.66	640.97							641.53	640.99
29-JUL-1992	780	31400	31600	638.81	639.23	639.99							640.93	640.74
04-AUG-1992	716	27600	26500	639.01	639.22	639.82	642.29	642.22		641.90		639.30	640.53	640.84
08-AUG-1992	682	21800	21000	639.21	639.34	639.74							640.63	640.84
16-AUG-1992	754	29500	28400	639.04	639.29	639.87							640.73	641.09
22-AUG-1992	577	14600	16200	639.10	639.19	639.41	642.09	642.19		641.70		639.30		
27-AUG-1992	574	16700	15300	638.97	639.03	639.33							640.63	640.94
18-SEP-1992	21000	47900	47001	639.24	639.86	641.16							646.53	644.76
22-SEP-1992	7530	61300	46700	638.70	639.76	641.38							646.53	644.44
30-SEP-1992	1770	20400	18100	638.74	638.90	639.29							642.18	641.29
04-OCT-1992	1460	19200	17300	639.19	639.27	639.56							641.83	641.04
15-OCT-1992	1350	43600	43600	639.03	639.65	640.88							641.83	641.04
26-OCT-1992	1160	28700	27400	639.18	639.41	640.04							641.53	640.71

Note:1 Black River staff gages set in the summer of 1991.
Note:2 Gage "0"'s for 1991 and January 1992 are as surveyed 17 February 1992 through 27 February 1992.
Note:3 Gage "0"'s resurveyed November 1992.
Note:4 1992 Gage water surface elevations were computed by the W.D.N.R.
Note:5 Black River flows for the 1991 & 1992 water years are the daily mean discharge at the U.S.G.S. gage near Galesville, Wisconsin.
Note:6 Black River flows for the 1993 water year is the provisional daily mean discharge at the U.S.G.S. gage near Galesville, Wisconsin.
Note:7 Gage #5 has been discontinued as of 8 May 1992 due to the loss of the tree that the gage was attached.
Note:8 Gage #2 data prior to 14 November 1991 has been lost due to ice before the gage was tied into a T.B.M.

APPENDIX D

Water Surface Elevation Gage Information
Black River Delta Area

Locations

Water level gages were set at various locations in the Black River Delta in the summer of 1991. These gages were tied into TBMs (Temporary Bench Marks) which were subsequently tied into vertical datum (NGVD, 1912 adj.). The following information describes gage location.

Gage 1 - This gage is located on the downstream side of a large overhanging tree downstream of the railroad bridges.

Gage 2 - Placed in a very small bay located where Dodge Chute leaves the main Black River channel. The bay is on the right bank of Dodge Chute. Most of Dodge chute is occluded with sand with a substantial willow growth above. The bay is very small and very close to the Black River channel.

Gage 3 - This gage is located approximately 200 yards downstream of the mouth of Dodge Chute a short distance upstream of the Brice Prairie Slough. The gage is very likely dry. The gage is located near the center of a "V" that can be seen in the trees. The gage is just downstream of a large sand pile which Dodge Chute has placed in the old channel bed.

Gage 4 - This gage was placed upstream of the entrance to Dodge 2 it was placed in water during moderately high flows in the Black River. It is currently reported to be above the water level. It may be obscured by grasses and willows in the summer. It should be easily located in the late fall or winter when leaves have fallen.

Gage 5 - This gage is placed in the channel downstream of the two channels as can be seen in the map. The gage is located on the edge of the channel. It is placed on the downstream side of a tree which encroaches slightly into the channel. The gage can be seen from an approach from the downstream direction.

Gage 6 - This gage is located on a small bay between the No Name Chute and Bullet Chute partial closure structures.

Gage 7 - This gage was placed on Shingle Creek. The gage is on a pier on the downstream side of bridge BR10 on the Trempealeau Bike Trail (the bridges are labeled). The gage is located closer to the left bank (south side of the channel).

Gage 8 - This gage was placed on Tank Creek. The gage is located downstream of bridge BR15 on the Trempealeau Bike Trail. The gage is on a piling toward the middle of the bridge. Gage can be read from the south shoreline of the creek.

Vertical Control

This is a summary of field surveys taken in February 1992. TBM locations and elevations are described. The railroad spike TBMs at each gage should be used for future gage data. The gages were also resurveyed 3 November 1992.

	T.B.M. ELEV.	T.B.M. NAME	T.B.M. description
GAGE #1	648.58	T.B.M.#1-A	Railroad spike 1' above ground on river side of 36" maple tree approx. 12' from rt. bank of river approx. 30' W. of gage #1
	651.35	T.B.M.#1-B	Top of anchor bolt on W. bolt at base of ladder on top of S.W. corner of B.N.R.R. bridge pier on rt. bank of Black River near gage #1
	650.10	T.B.M.#1-C	Found nail 3' above ground in same tree described in T.B.M.#1-A
			639.79 = Gage #1 "0" as of 19FEB92 Gage #1 is leaning at a 45 degree angle and needs to be reset - 3NOV92
GAGE #2	648.02	T.B.M.#2-A	Railroad spike 1' above ground in N. side of 12" maple tree approx 50' E. of left bank of Black River and 6' from right bank of Dodge Chute approx. 15' S.E. of gage #2
	649.25	T.B.M.#2-B	Found nail 3.5' above ground on S. side of 10" yellow birch approx. 5' N. of tree described in T.B.M. #2-A
			640.49 Gage #2 "0" as of 19FEB92 640.50 Gage #2 "0" as of 3NOV92 Gage found in good shape - 3NOV92
GAGE #3	646.96	T.B.M.#3-A	Railroad spike 1' above ground in W. side of 18" maple tree approx. 30' back from left bank of old Dodge Chute and left bank of Brice Prairie channel approx. 30' S.E. of Gage #3
	647.65	T.B.M.#3-B	Found nail 2' above ground in same tree described by T.B.M.#3-A
			642.25 Gage #3 "0" as of 19FEB92 642.04 Gage #3 "0" as of 3NOV92 Gage found leaning slightly - 3NOV92 Gage moved ?
GAGE #4	646.47	T.B.M.#4-A	Railroad spike 1' above ground on landward side of 18" maple tree approx. 70' back from left bank of Black River and 70' N. of Gage #4
	648.57	T.B.M.#4-B	Found nail 4' above ground in same tree described in T.B.M.#4-A
			640.28 Gage #4 "0" as of 19FEB92 640.27 Gage #4 "0" as of 3NOV92 Gage found in good shape - 3NOV92

	T.B.M. ELEV.	T.B.M. NAME	T.B.M. description
GAGE #5	643.12	T.B.M.#5-A	Railroad spike 1' above ground on landward side of 12" maple tree in cluster approx. 25' back from left bank of Dodge Chute and approx. 35' S. of gage #5
	646.34	T.B.M.#5-B	Found nail 5' above ground on riverward side of 18" maple tree located approx. 12' N. of T.B.M.#5-A
	642.84	T.B.M.#5-C	Found nail 2' above ground on D.S. side of 10" cluster of maple trees on left bank of Dodge Chute 2' U.S. from gage #5
			637.96 Gage #5 "0" as of 19FEB92 Gage #5 destroyed - 3NOV92 When was Gage destroyed ?
GAGE #6	642.11	T.B.M.#6-A	Railroad spike 1' above ground in N. side of 8" birch tree on bank of channel approx. 15' S.E. of gage #6
	644.30	T.B.M.#6-B	Found nail 4' above ground in same tree described in T.B.M.#6-A
	645.53	T.B.M.#6-C	Found nail 4.5' above ground in 8" maple tree on bank of channel approx. 28' S.E. of gage #6
			638.47 Gage #6 "0" as of 27FEB92 639.06 Gage #6 "0" as of 3NOV92 Gage found in good shape - 3NOV92 Gage moved ?
GAGE #7	648.40	T.B.M.#7-A	Railroad spike in end of cap beam at left D.S. corner (S.E.) of bike trail bridge (#B10) over Shingle Creek in S.E.1/4 Sec. 5, T.17N.-R8W. near gage #7
			638.53 Gage #7 "0" as of 20FEB92 638.52 Gage #7 "0" as of 3NOV92 Gage found in good shape - 3NOV92
GAGE #8	648.55	T.B.M.#8-A	Railroad spike in end of cap beam at left U.S. corner(N.E.) of bike trail bridge(#B15) over Tank Creek near gage #8 in N.E. 1/4 Sec.6,T.17N.-R.8W.
	646.98	T.B.M.#8-B	Found nail in D.S. side of second pile bent pier from W. side of same bridge (#B15) described by T.B.M.#8-A
			638.69 Gage #8 "0" as of 20FEB92 638.69 Gage #8 "0" af of 3NOV92 Gage found in good shape - 3NOV92

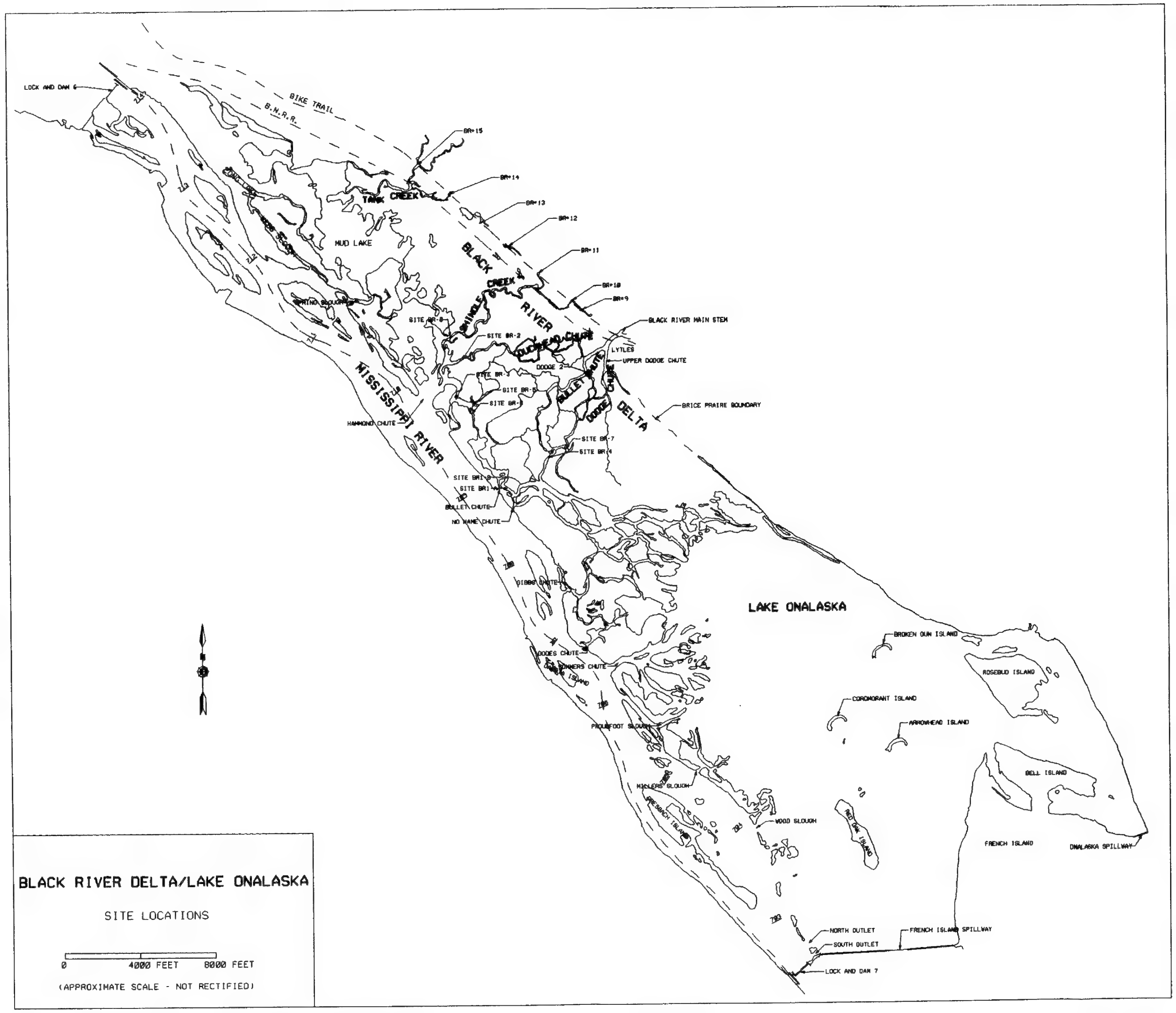

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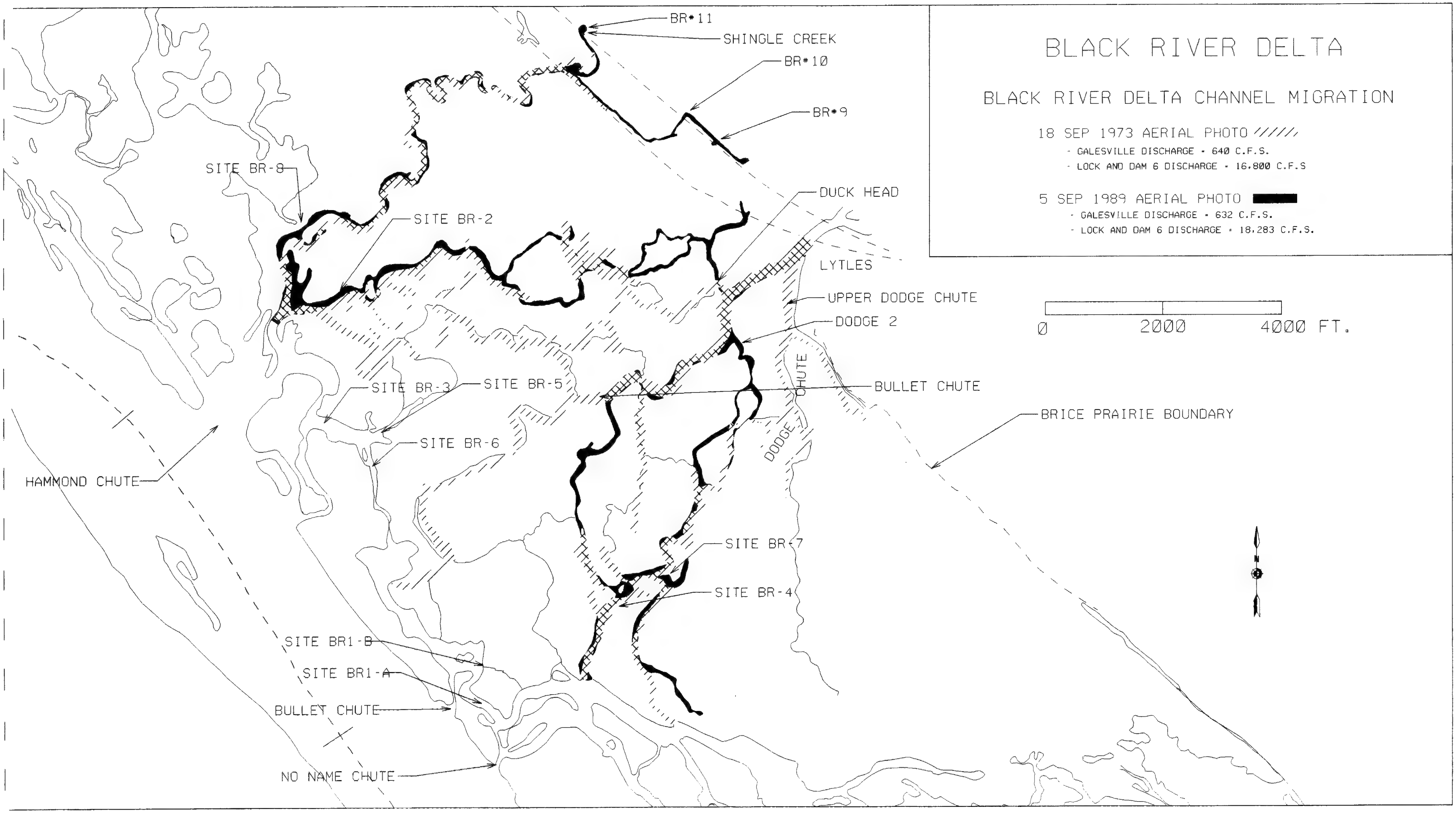
Figure 1



c:\dgn\upoo172.dgn Jul. 19, 1994 06:15:41

Figure 2

MISSISSIPPI RIVER
LOCK AND DAM POOL NUMBER 6
ANNUAL FLOW DURATION CURVE

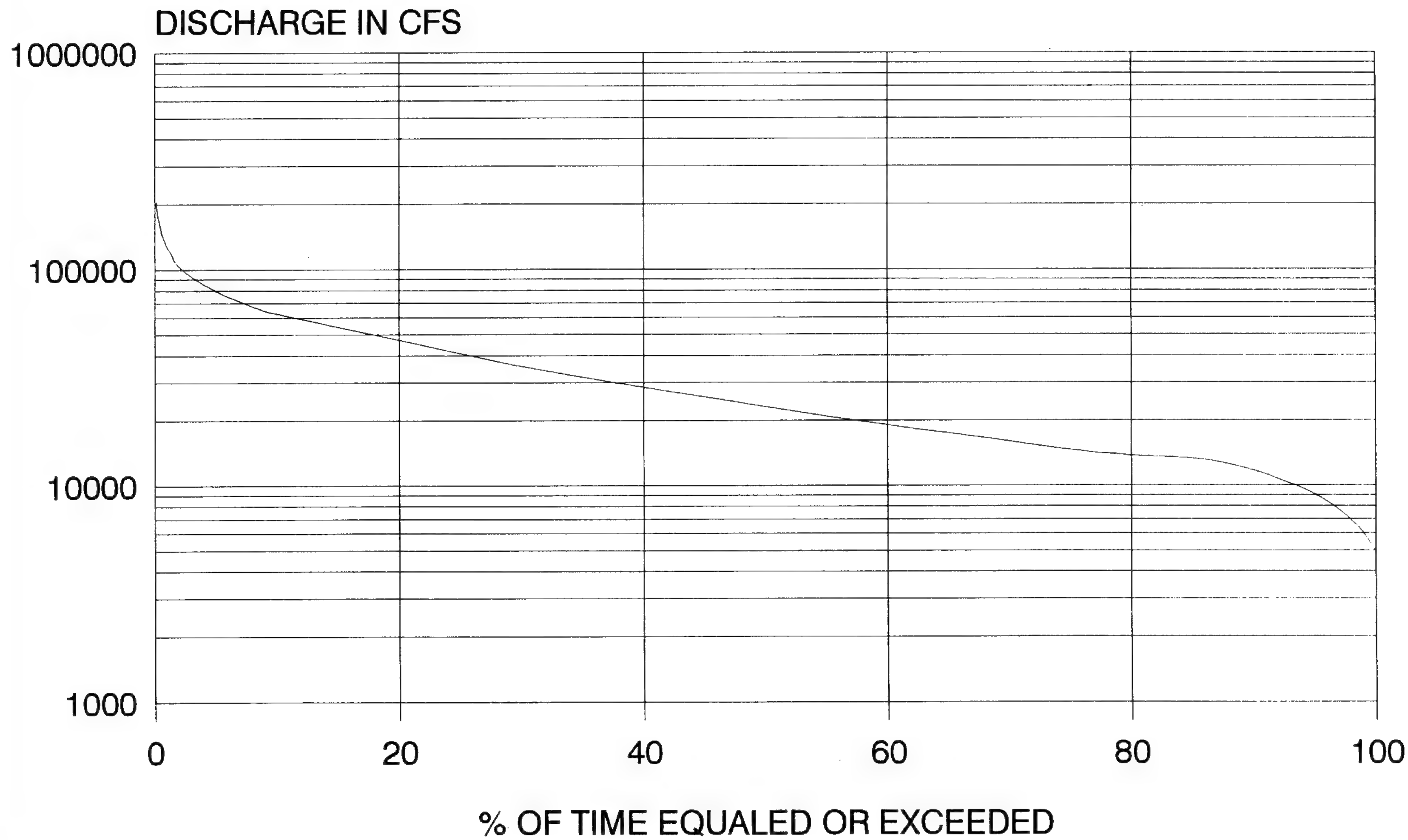


Figure 3

BLACK RIVER NEAR GALESVILLE, WI
STATION ID - 5382000
ANNUAL FLOW DURATION CURVE

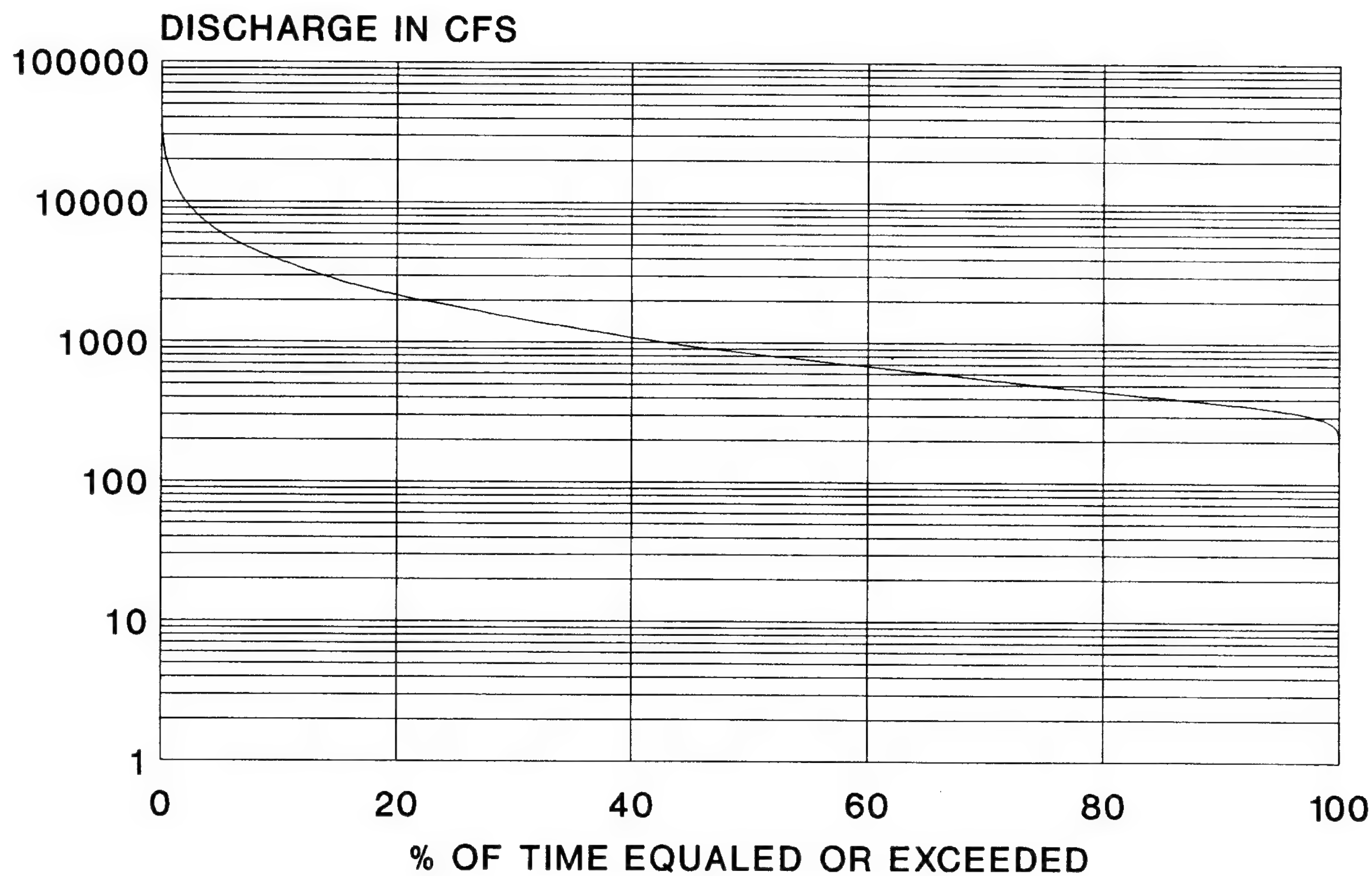
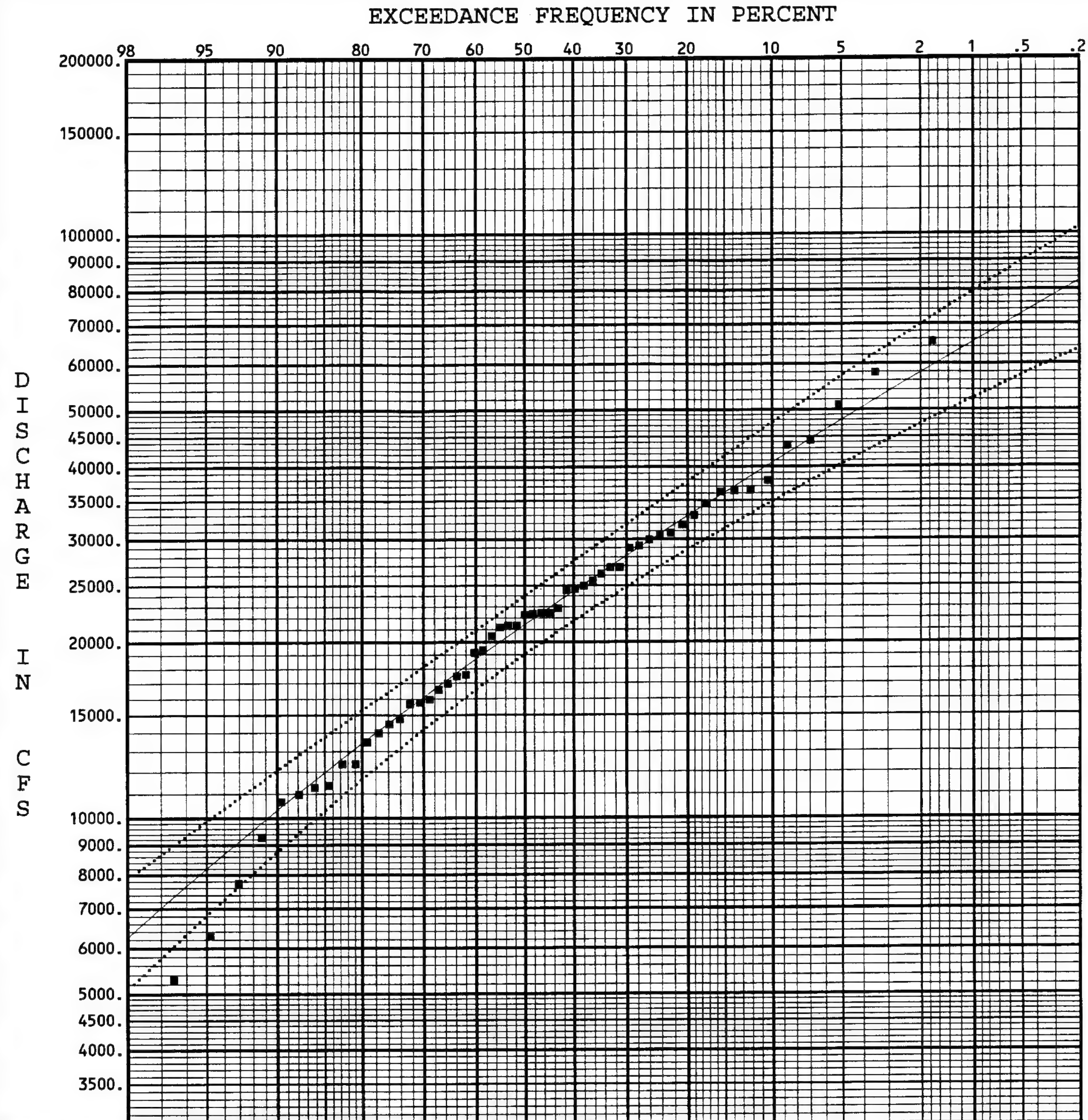


Figure 4



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10300.	.900
8230.	.950
5180.	.990

MEAN LOGARITHM	4.3204
STANDARD DEVIATION	.2280
COMPUTED SKEW	-.2957
GENERALIZED SKEW	-.2000
ADOPTED SKEW	-.3000
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HIGH OUTLIERS	0
LOW OUTLIERS	1
ZERO OR MISSING	0
SYSTEMATIC EVENTS	57

BLACK RIVER NEAR
GALESVILLE, WISCONSIN

EXPECTED PROBABILITY
DISCHARGE-FREQUENCY CURVE
WEIBULL PLOTTING POSITIONS

USGS ID Number	05382000
Period of Record	1932-1988
Drainage Area	2080.0

MMZ

Figure 5

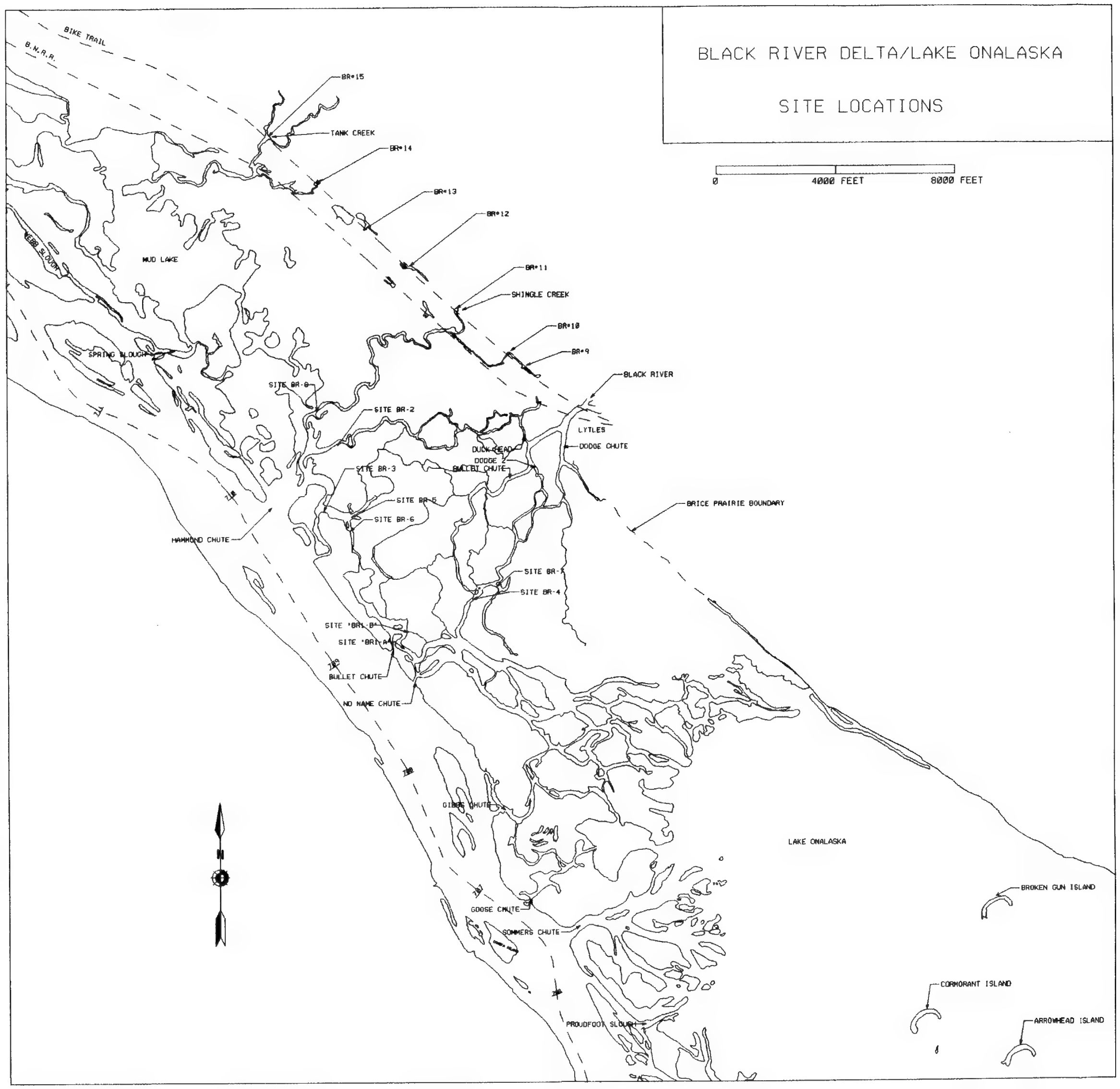

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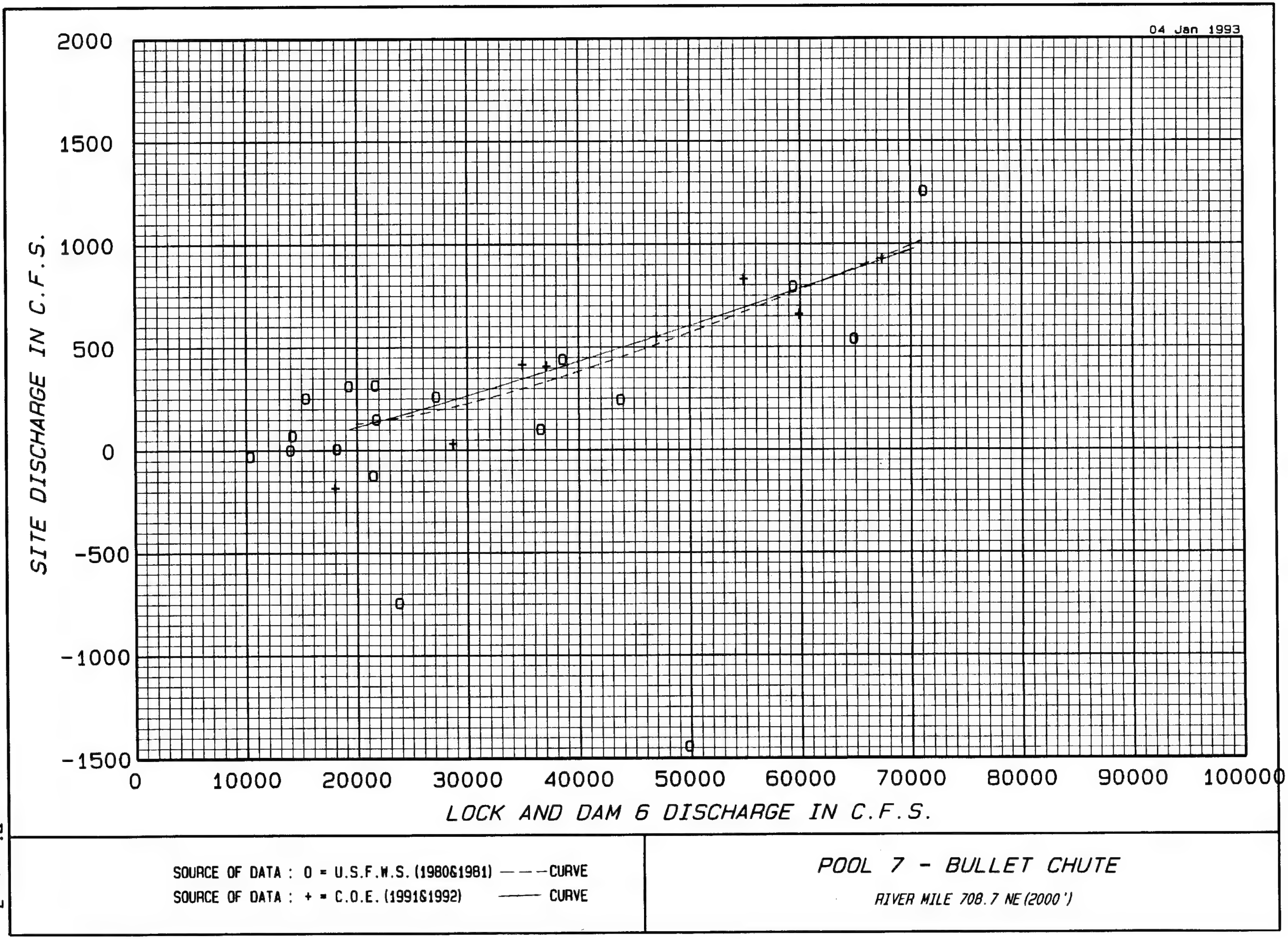
Figure 6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1000
500
0
-500
-1000
-1500
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30000
40000
50000
60000
70000
80000
90000
100000
LOCK AND DAM 6 DISCHARGE IN C.F.S.
SOURCE OF DATA : O = U.S.F.W.S. (1980&1981) ---CURVE
SOURCE OF DATA : + = C.O.E. (1991&1992) —— CURVE
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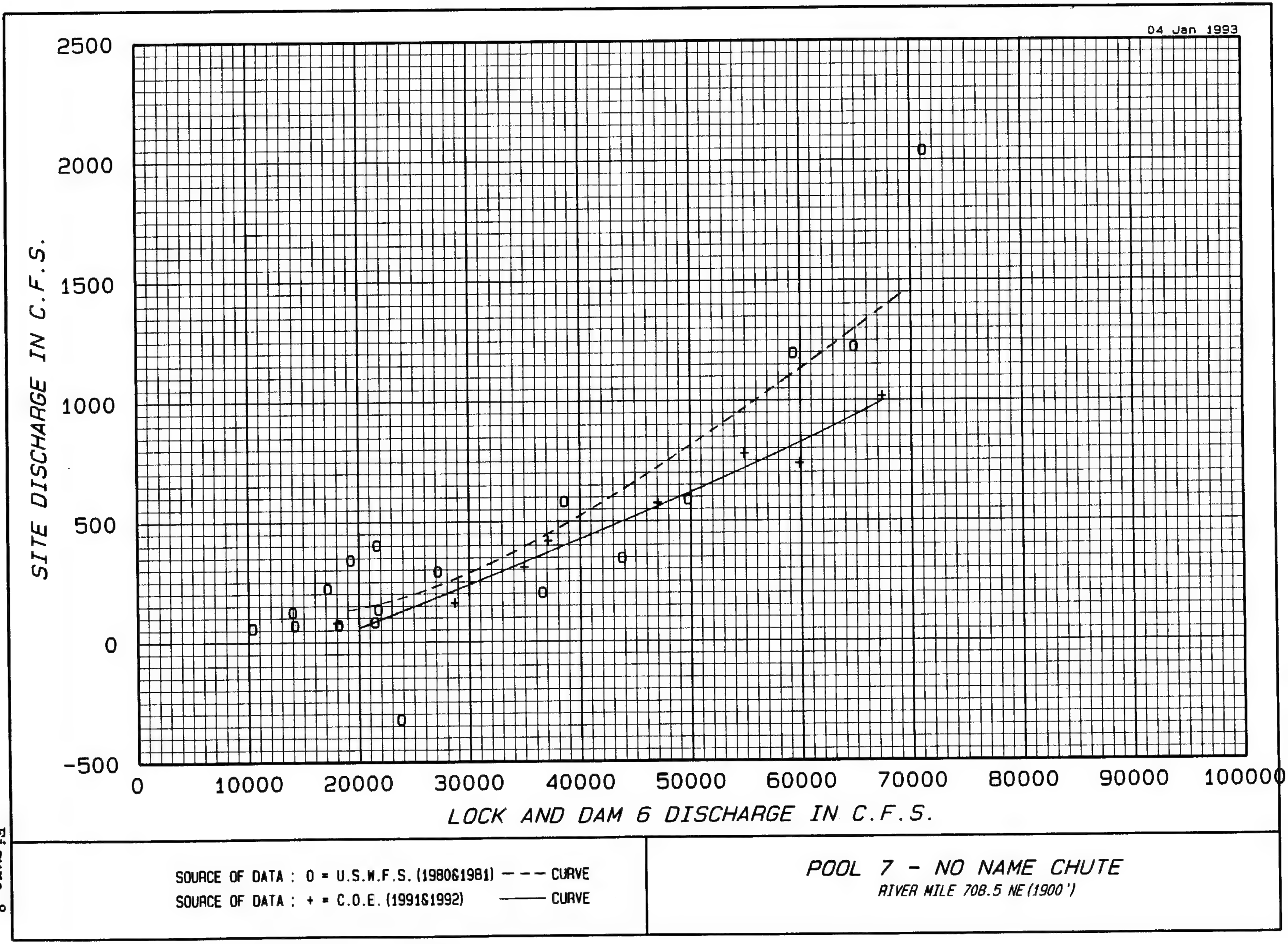
RIVER MILE 708.7 NE (2000')

Figure 7


04 Jan 1993
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2000
1500
1000
500
0
-500
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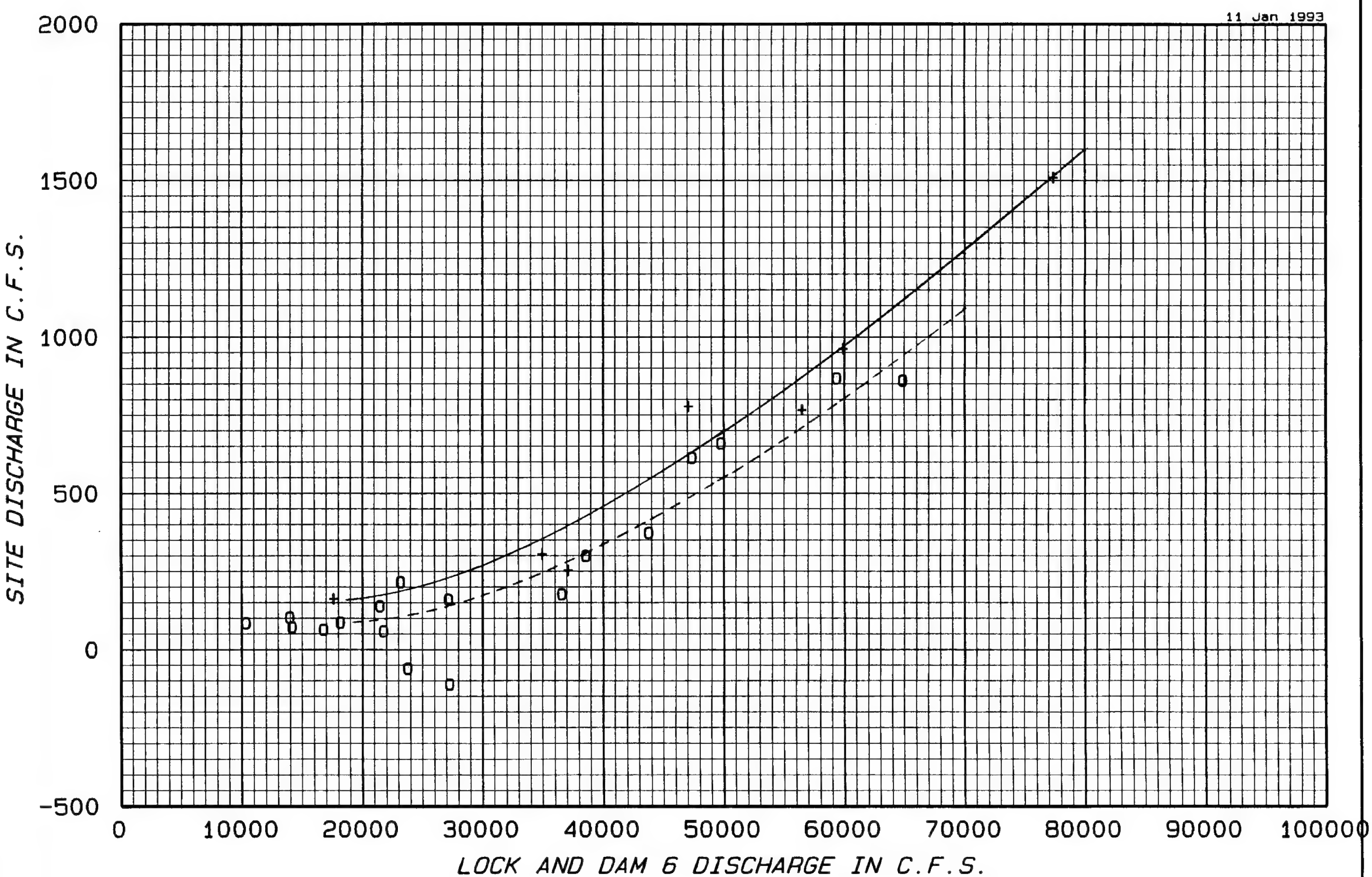
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
LOCK AND DAM 6 DISCHARGE IN C.F.S.
SOURCE OF DATA : 0 = U.S.W.F.S. (1980&1981) - - - CURVE
SOURCE OF DATA : + = C.O.E. (1991&1992) ——— CURVE
POOL 7 - NO NAME CHUTE
RIVER MILE 708.5 NE (1900')

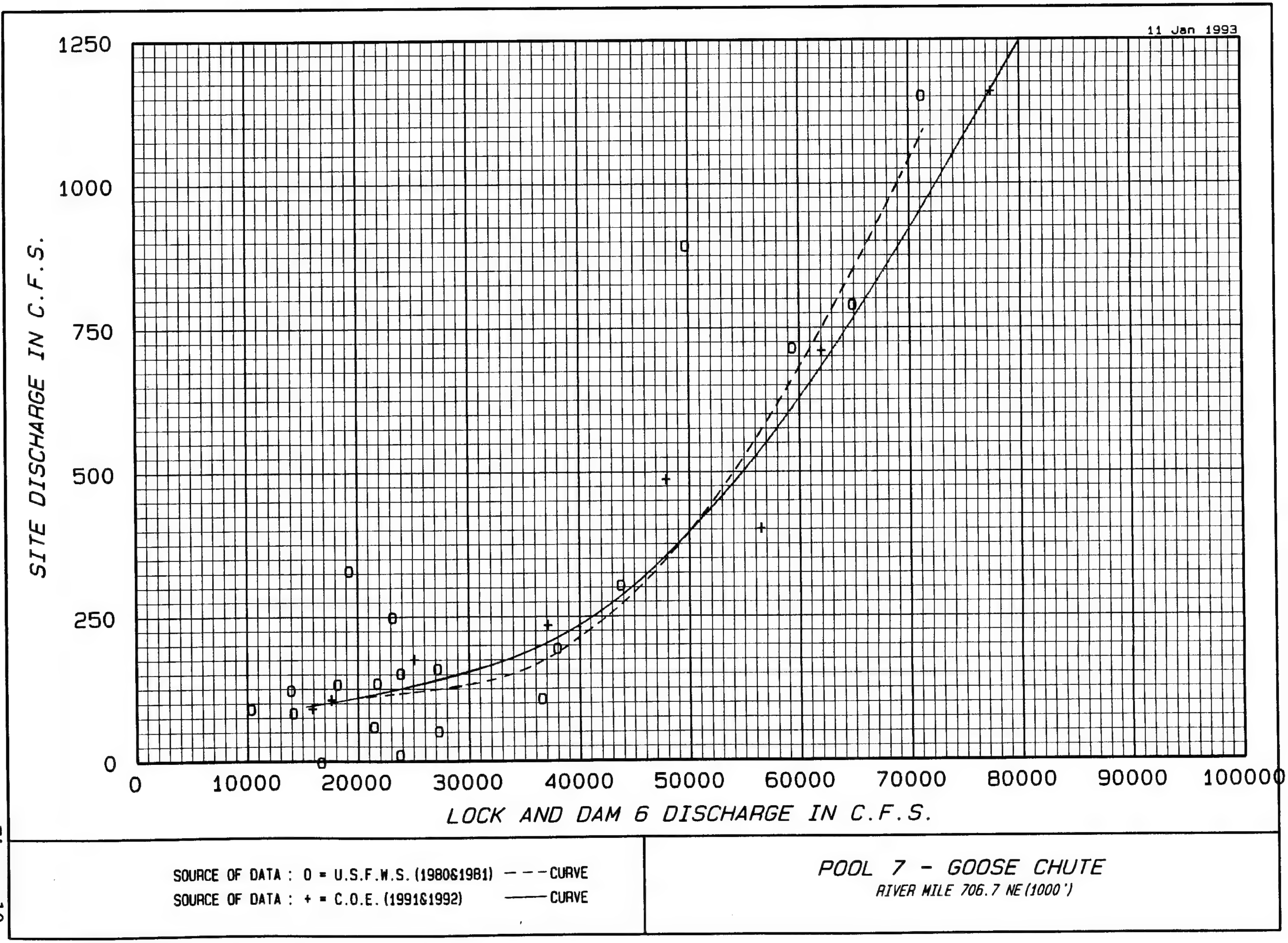
Figure 8



SOURCE OF DATA : O = U.S.F.W.S. (1980&1981) - - - CURVE
SOURCE OF DATA : + = C.O.E. (1991&1992) ——— CURVE

POOL 7 - GIBBS CHUTE
RIVER MILE 707.6 E (2200')

Figure 9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0
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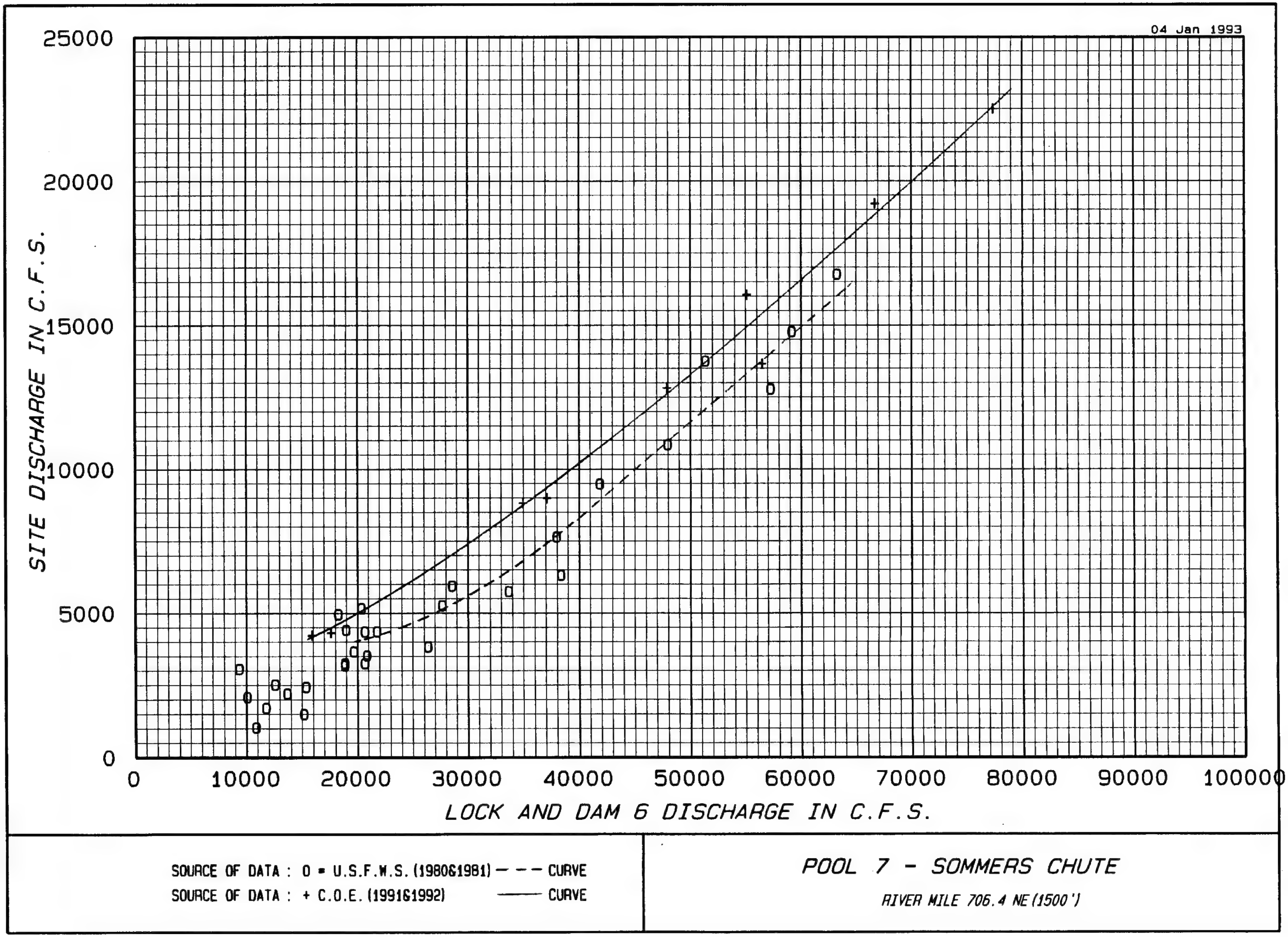
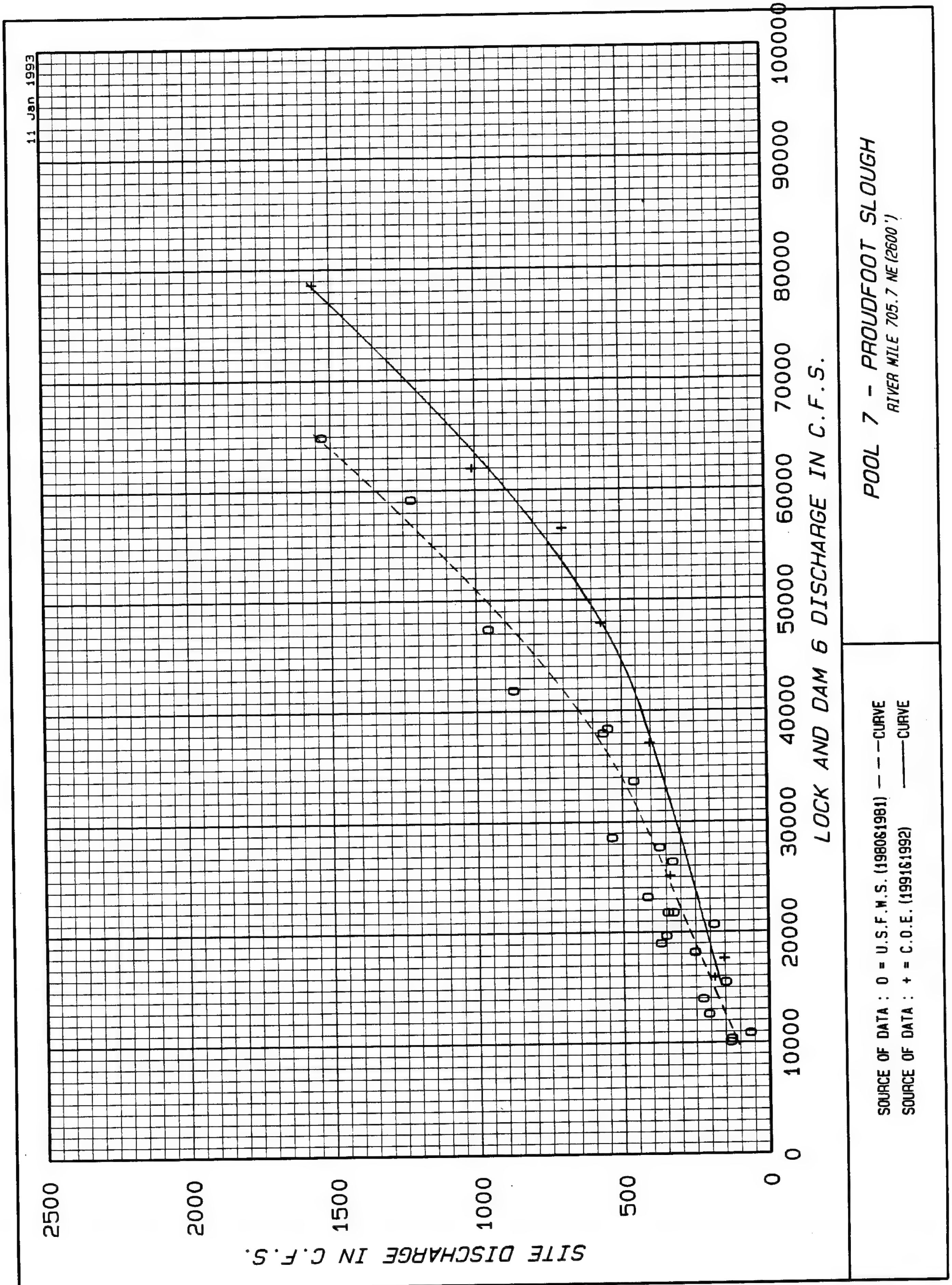
30000
40000
50000
60000
70000
80000
90000
100000
LOCK AND DAM 6 DISCHARGE IN C.F.S.
SOURCE OF DATA : O = U.S.F.W.S. (1980&1981) - - - CURVE
SOURCE OF DATA : + = C.O.E. (1991&1992) —— CURVE
POOL 7 - GOOSE CHUTE
RIVER MILE 706.7 NE (1000')

Figure 10



04 Jan 1993
25000
20000
15000
10000
5000
0
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
LOCK AND DAM 6 DISCHARGE IN C.F.S.
SOURCE OF DATA : O = U.S.F.W.S. (1980&1981) – – – CURVE
SOURCE OF DATA : + C.O.E. (1991&1992) ——— CURVE
POOL 7 - SOMMERS CHUTE
RIVER MILE 706.4 NE (1500')

Figure 11



11 Jan 1993
POOL 7 - PROUDFOOT SLOUGH
RIVER MILE 705.7 NE (2600')
LOCK AND DAM 6 DISCHARGE IN C.F.S.
SITE DISCHARGE IN C.F.S.
SOURCE OF DATA : O = U.S.F.W.S. (1980&1981) - - -CURVE
SOURCE OF DATA : + = C.O.E. (1991&1992) ———CURVE
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10000
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1000
1500
2000
2500

Figure 12

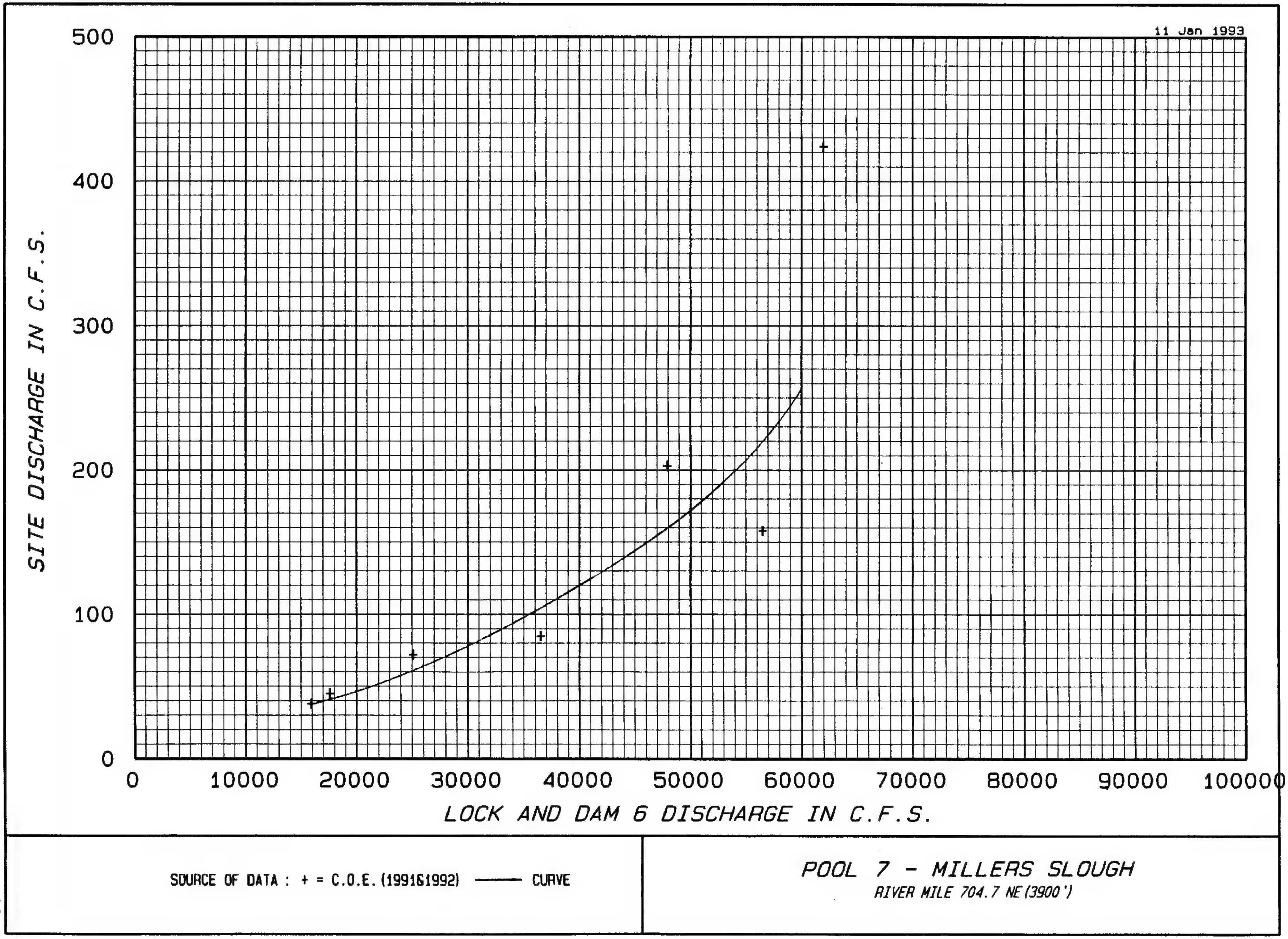
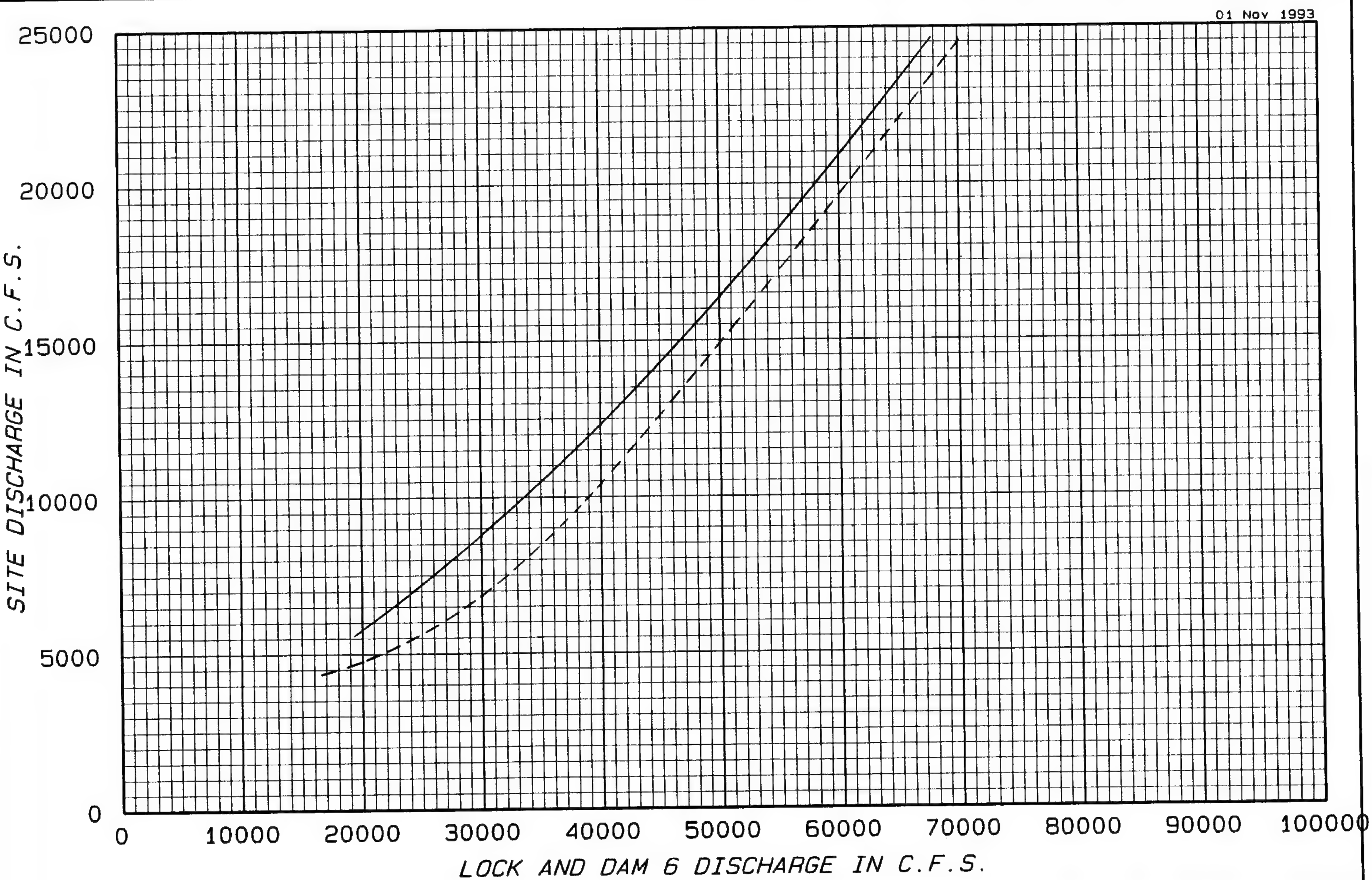

11 Jan 1993
500
400
300
200
100
0
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
LOCK AND DAM 6 DISCHARGE IN C.F.S.
SOURCE OF DATA : + = C.O.E. (1991&1992) ——— CURVE
POOL 7 - MILLERS SLOUGH
RIVER MILE 704.7 NE (3900')

Figure 13

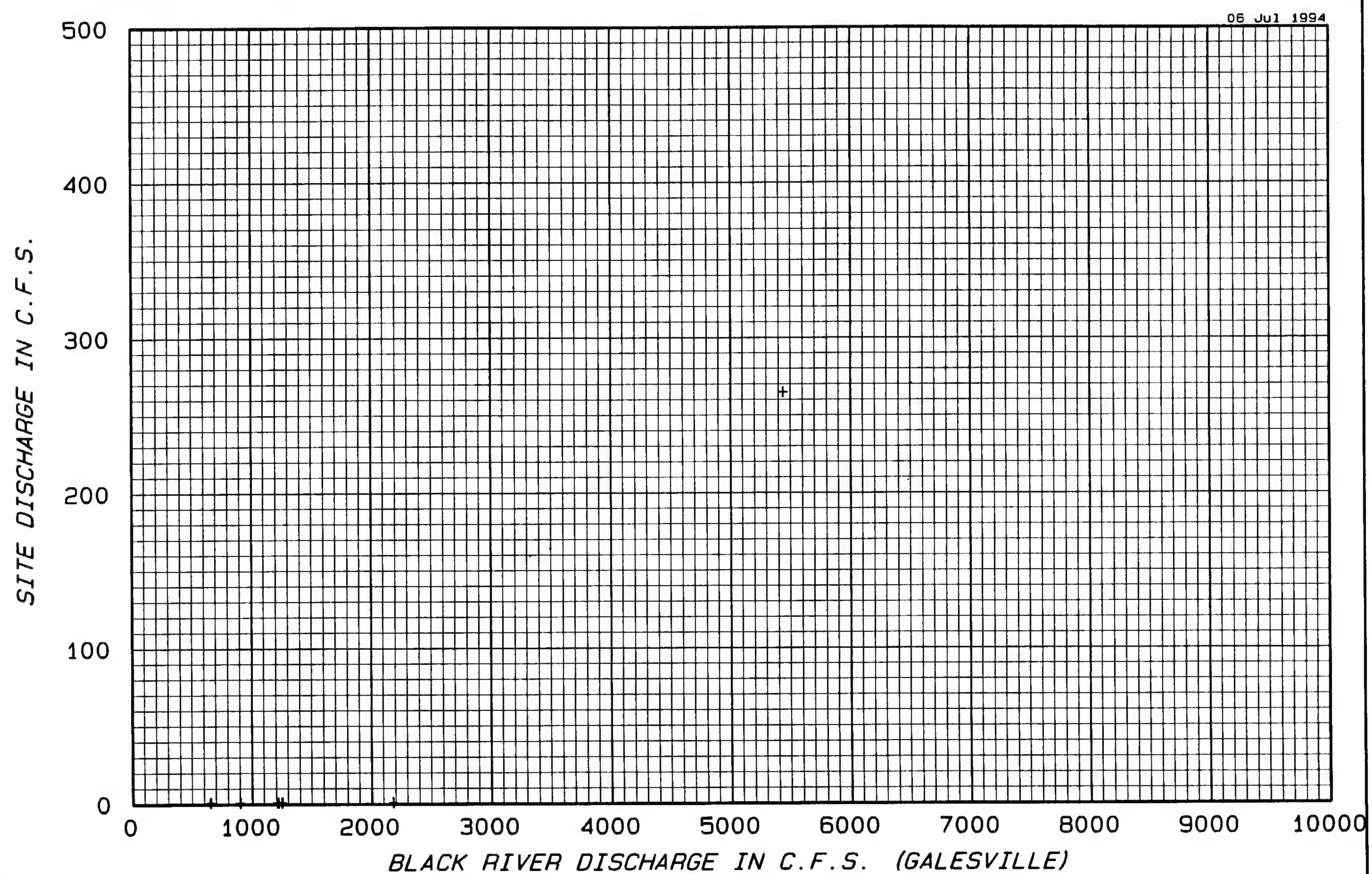


SOURCE OF DATA: 0 = U.S.F.W.S. (1980&1981) - - -CURVE
SOURCE OF DATA: + = C.O.E. (1991&1992) ——— CURVE

POOL 7 - LAKE ONALASKA

TOTAL MISSISSIPPI RIVER FLOW INTO LAKE ONALASKA THROUGH SECONDARY CHANNELS BETWEEN BULLET CHUTE AND MILLERS SLOUGH

Figure 14

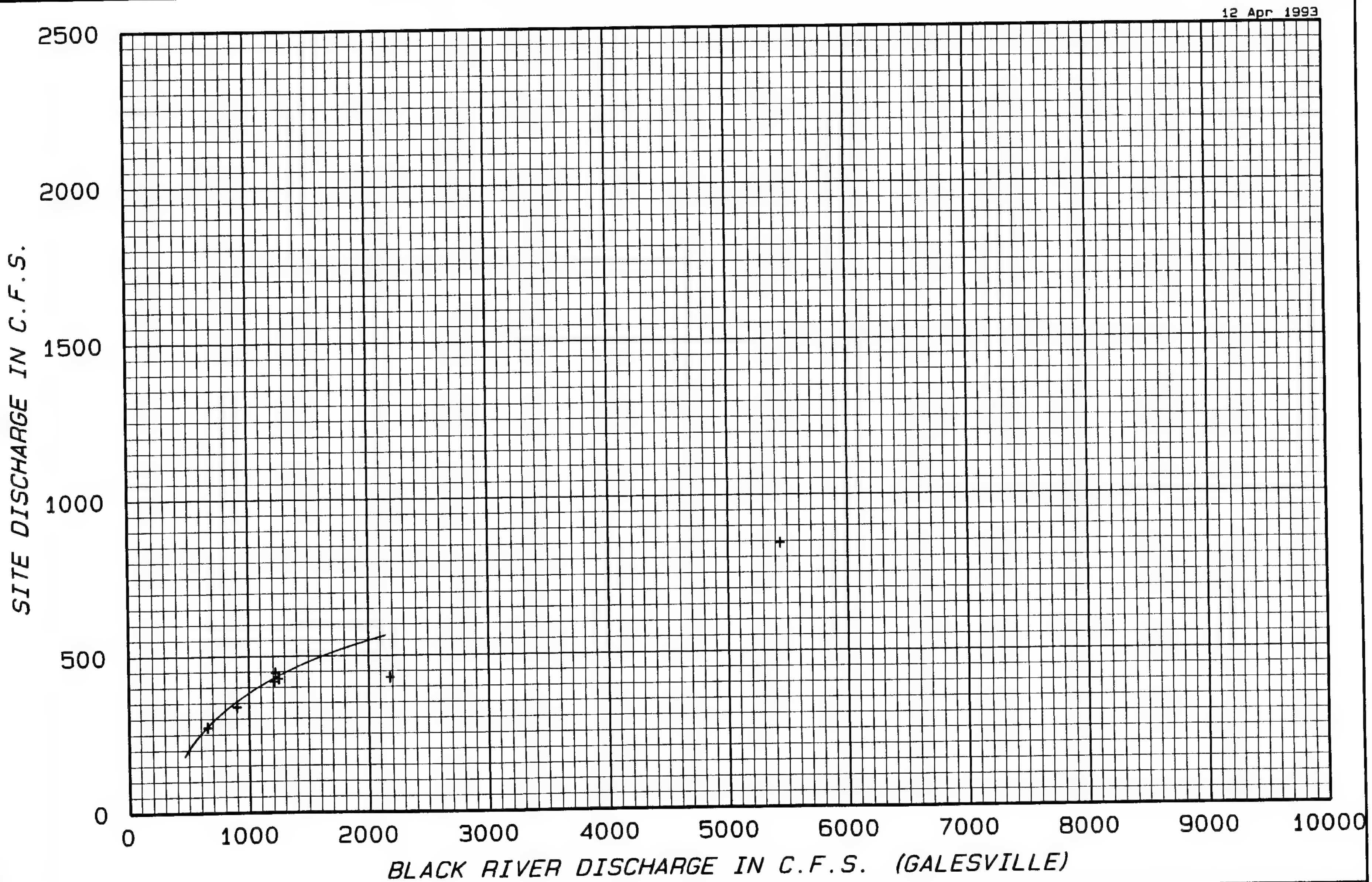


SOURCE OF DATA : + = W.D.N.R. (1991&1992)

BLACK RIVER - DODGE CHUTE

RIVER MILE 709.0 NE (10000')

Figure 15



SOURCE OF DATA : + = W.D.N.R. (1991&1992)

BLACK RIVER - DODGE 2

RIVER MILE 709.0 NE (8700')

Figure 16

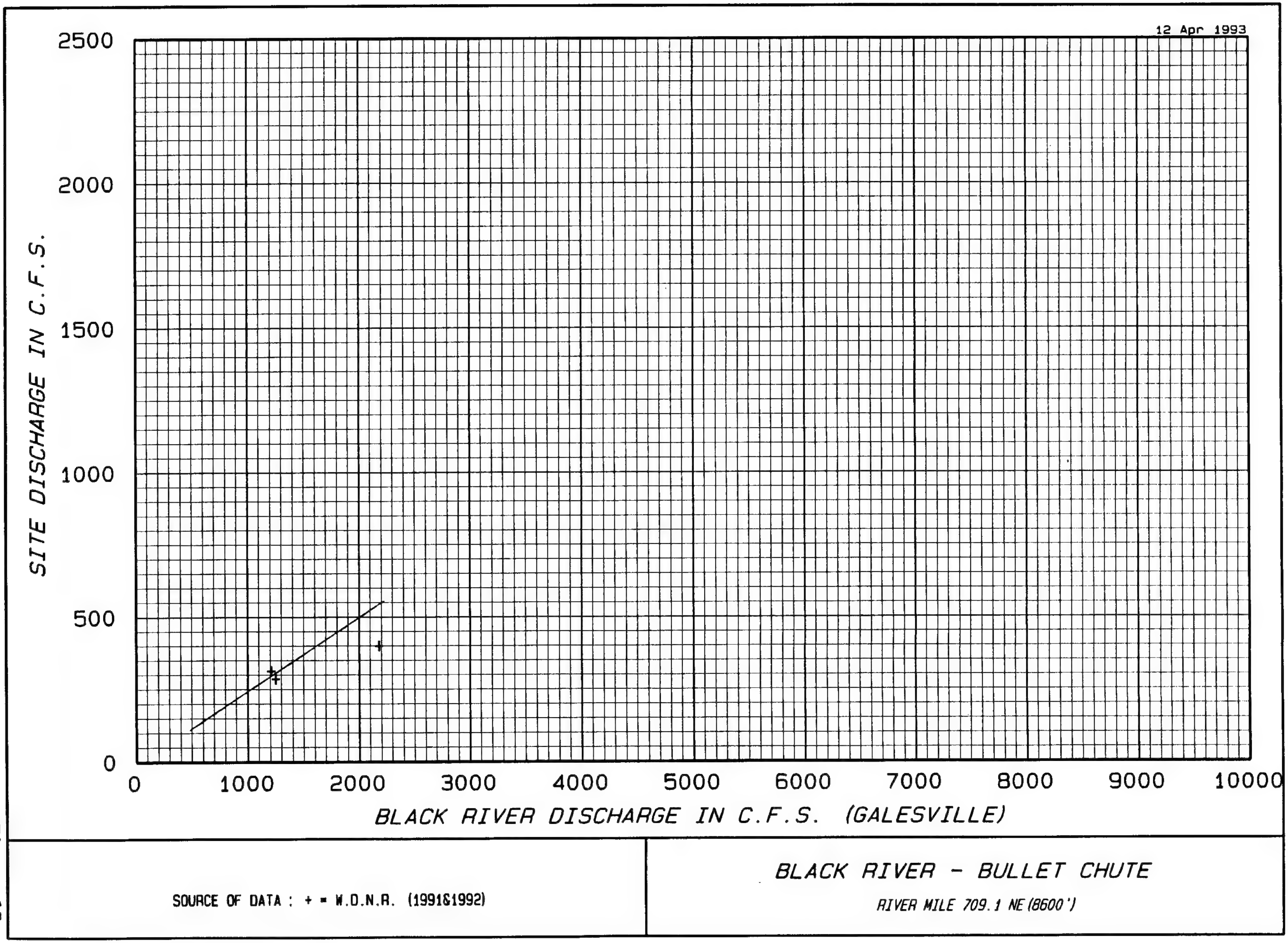

12 Apr 1993
2500
2000
1500
1000
500
0
SITE DISCHARGE IN C.F.S.
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
SOURCE OF DATA : + = W.D.N.R. (1991&1992)
BLACK RIVER - BULLET CHUTE
RIVER MILE 709.1 NE (8600')

Figure 17

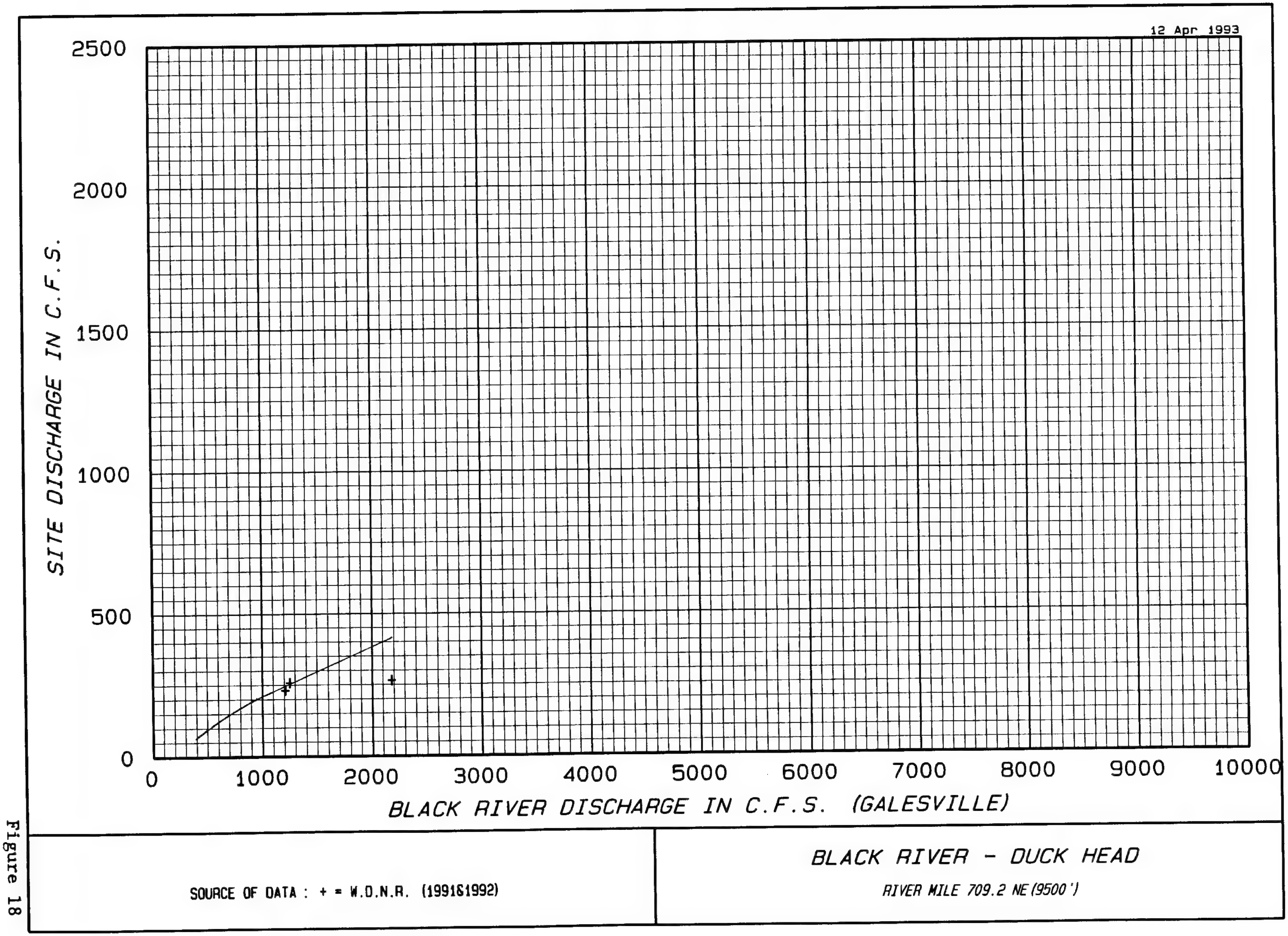

12 Apr 1993
2500
2000
1500
1000
500
0
SITE DISCHARGE IN C.F.S.
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
SOURCE OF DATA : + = W.D.N.R. (1991&1992)
BLACK RIVER - DUCK HEAD
RIVER MILE 709.2 NE (9500')

Figure 18

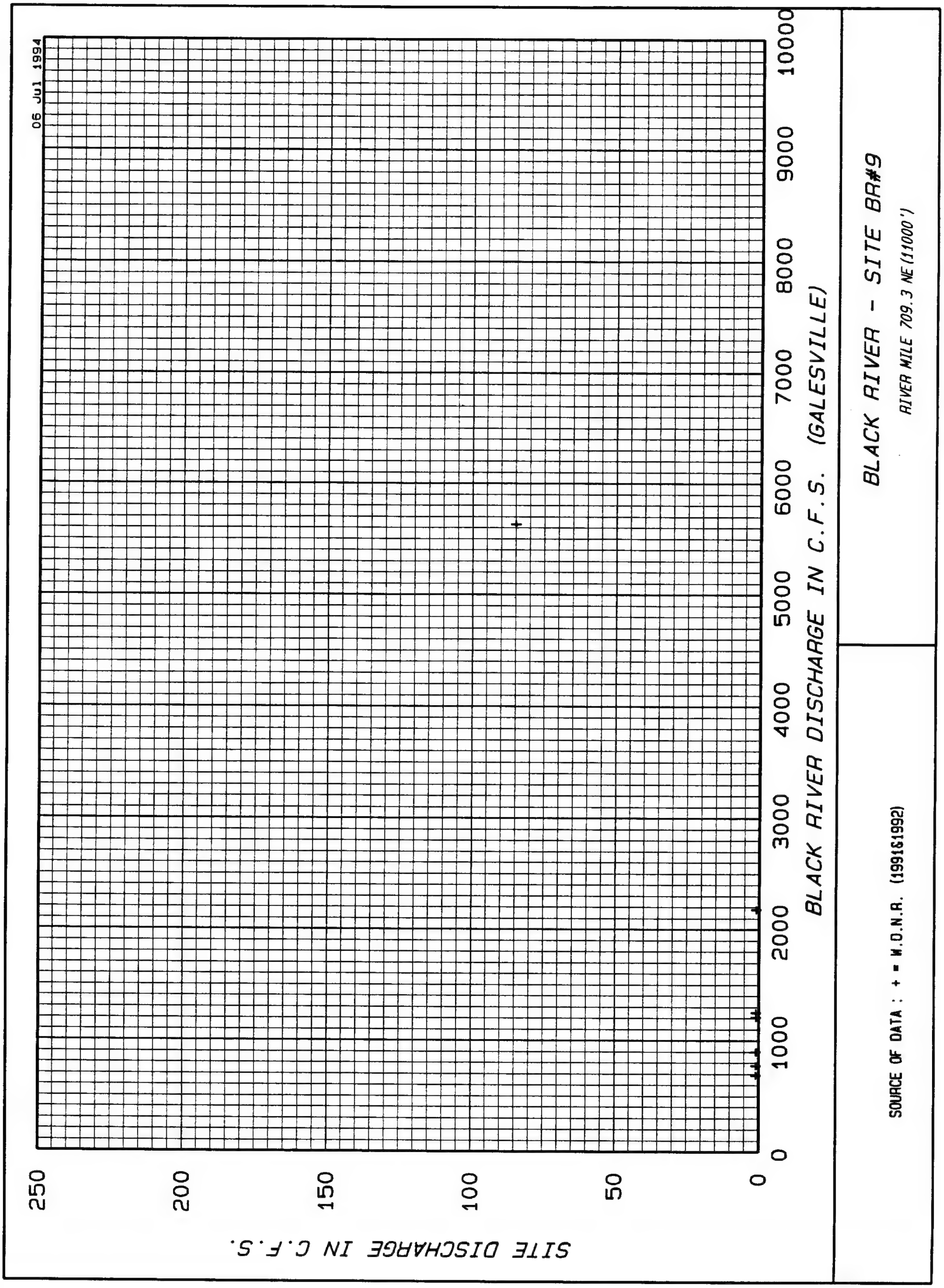
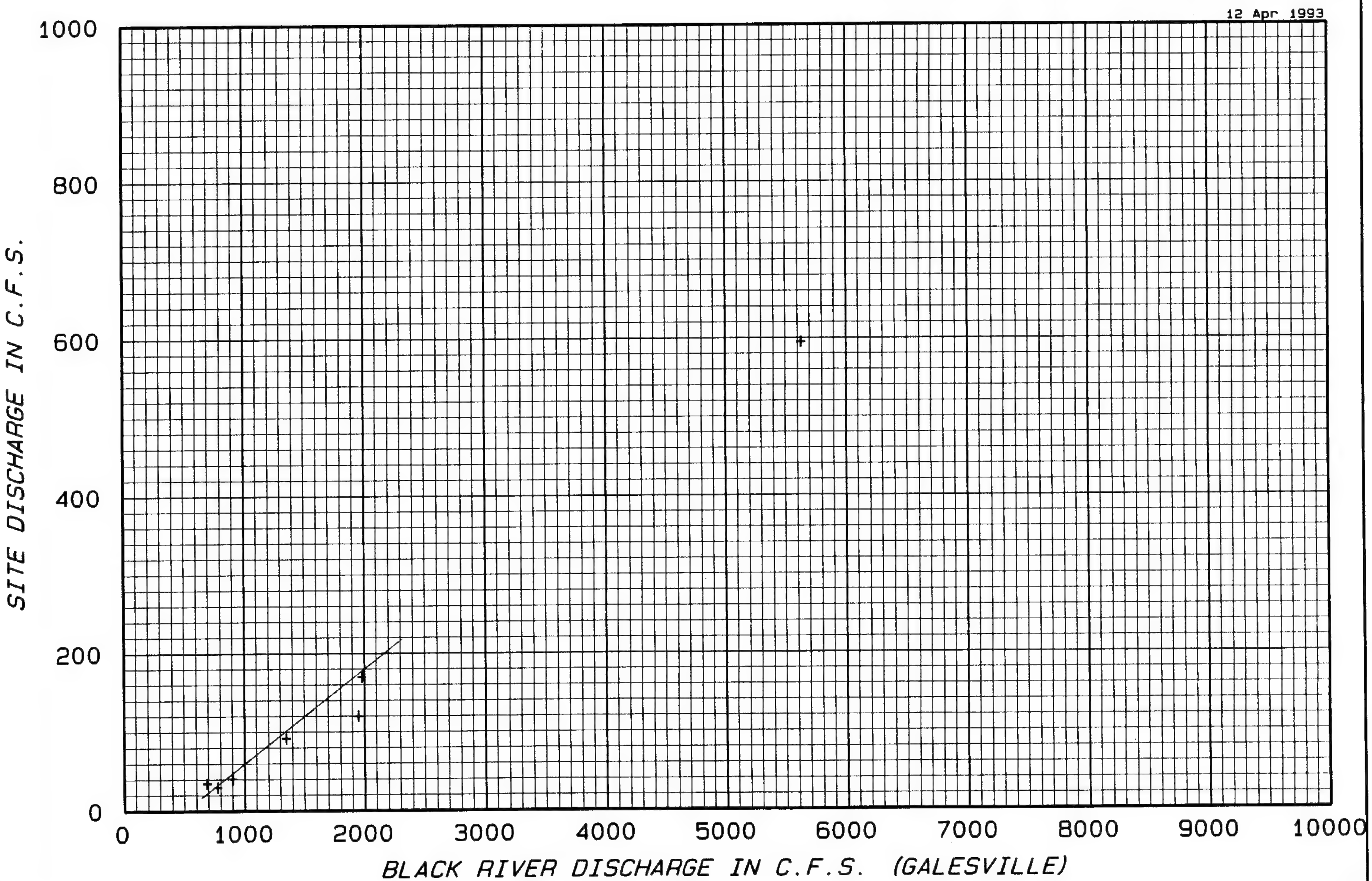

06 Jul 1994
SITE DISCHARGE IN C.F.S.
0
50
100
150
200
250
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
BLACK RIVER - SITE BR#9
RIVER MILE 709.3 NE (11000')
SOURCE OF DATA : + = W.D.N.R. (1991&1992)

Figure 19

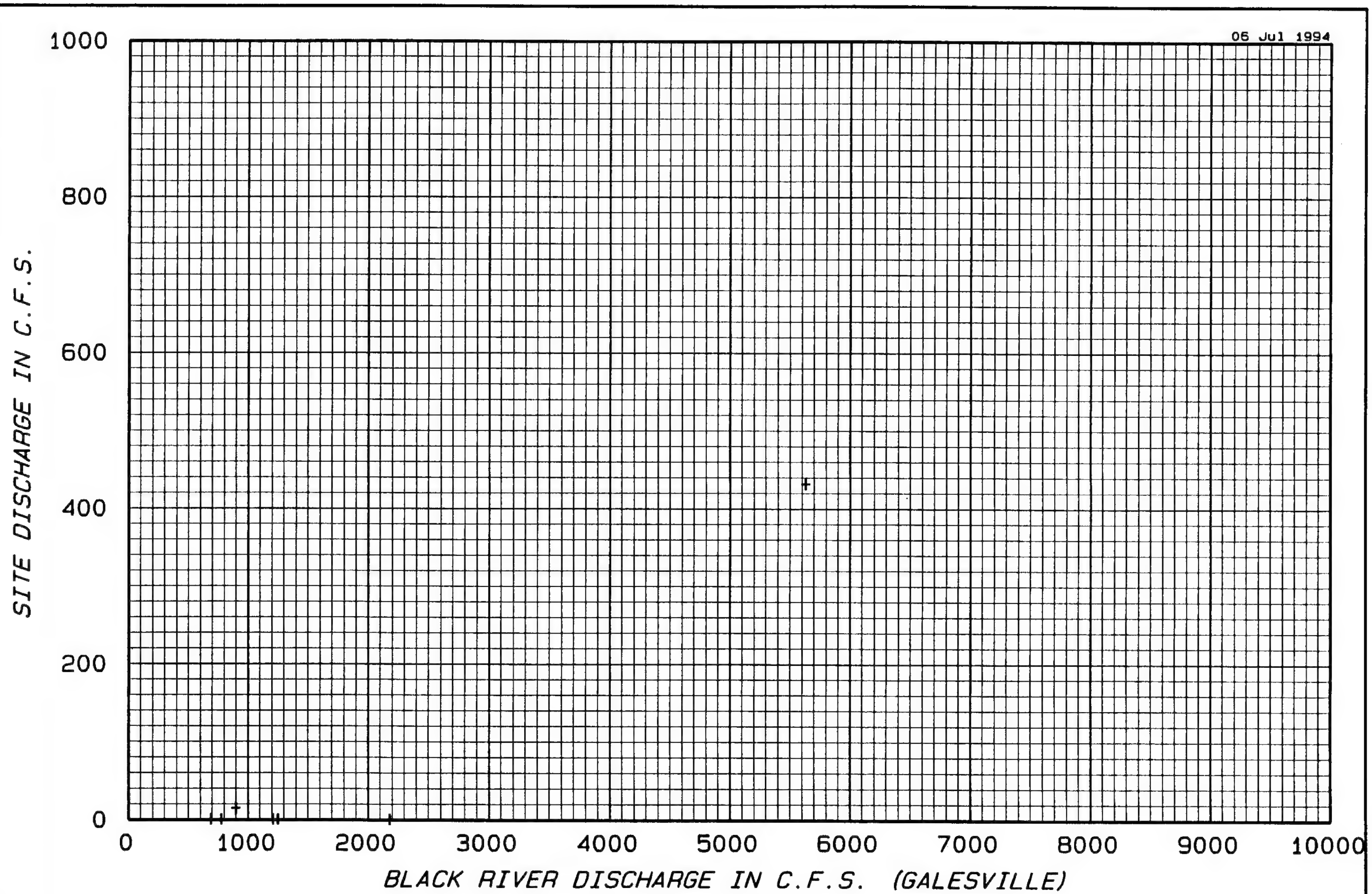


SOURCE OF DATA : + = W.D.N.R. (1991&1992)

BLACK RIVER - SITE BR#10

RIVER MILE 709.5 NE (10700')

Figure 20

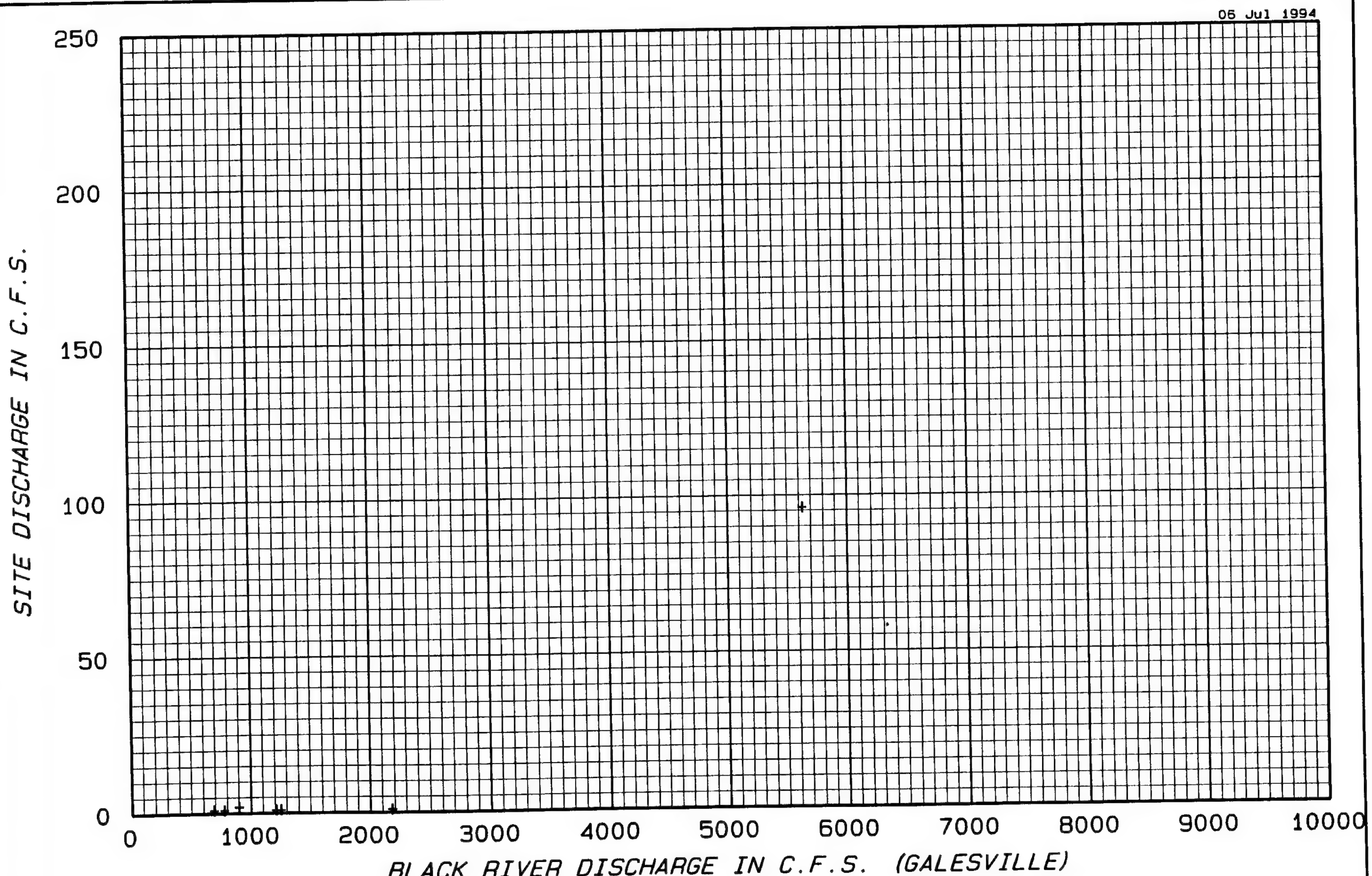


SOURCE OF DATA : + = W.D.N.R. (1991&1992)

BLACK RIVER - SITE BR#11

RIVER MILE 709.8 NE (10000')

Figure 21

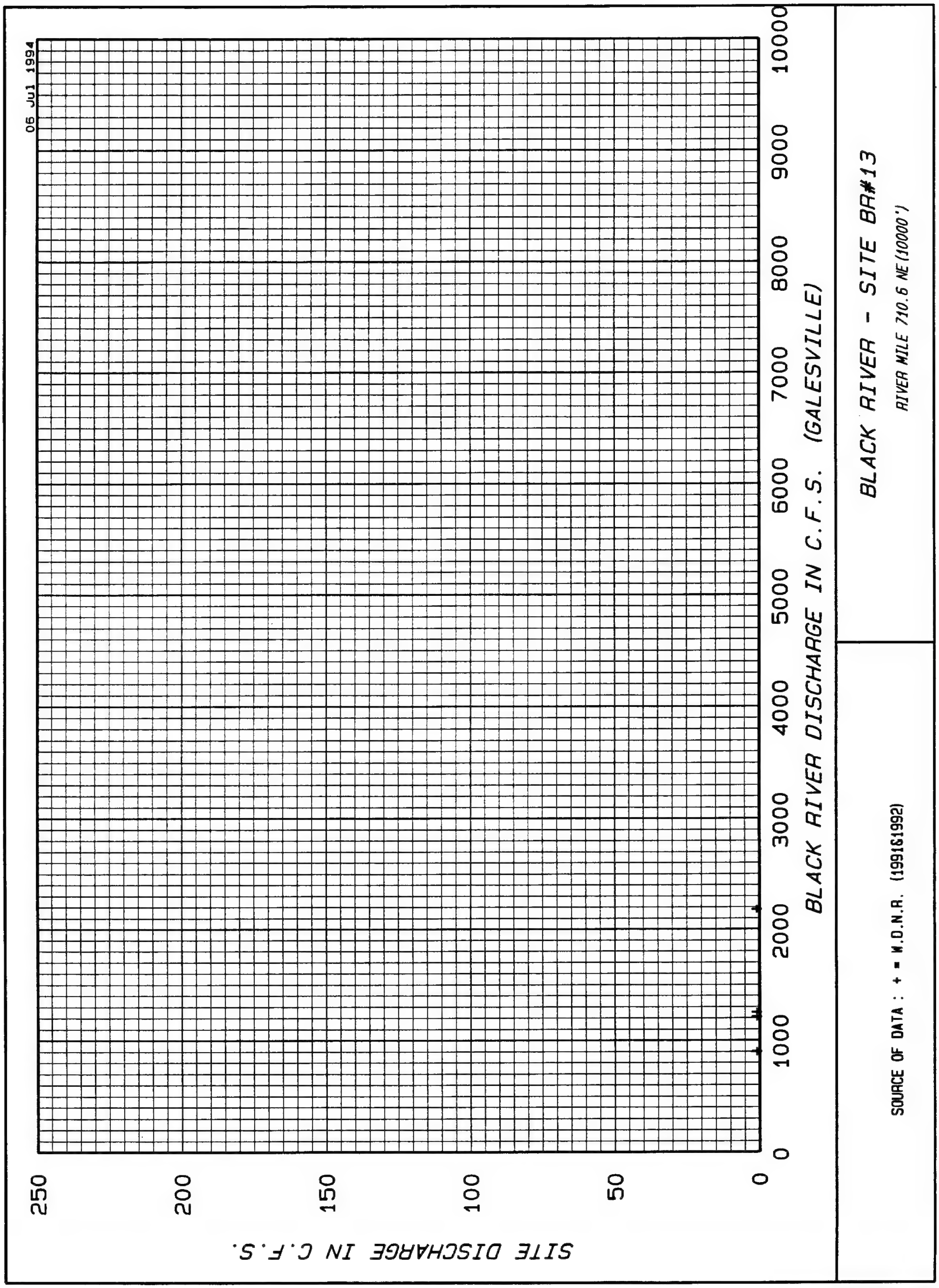


SOURCE OF DATA : + = W.D.N.R. (19916992)

BLACK RIVER - SITE BR#12

RIVER MILE 710.2 NE (9500')

Figure 22



06 Jul 1994
BLACK RIVER - SITE BR#13
RIVER MILE 710.6 NE (10000')
SOURCE OF DATA : + = W.D.N.R. (1991&1992)
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
SITE DISCHARGE IN C.F.S.
0
50
100
150
200
250

Figure 23

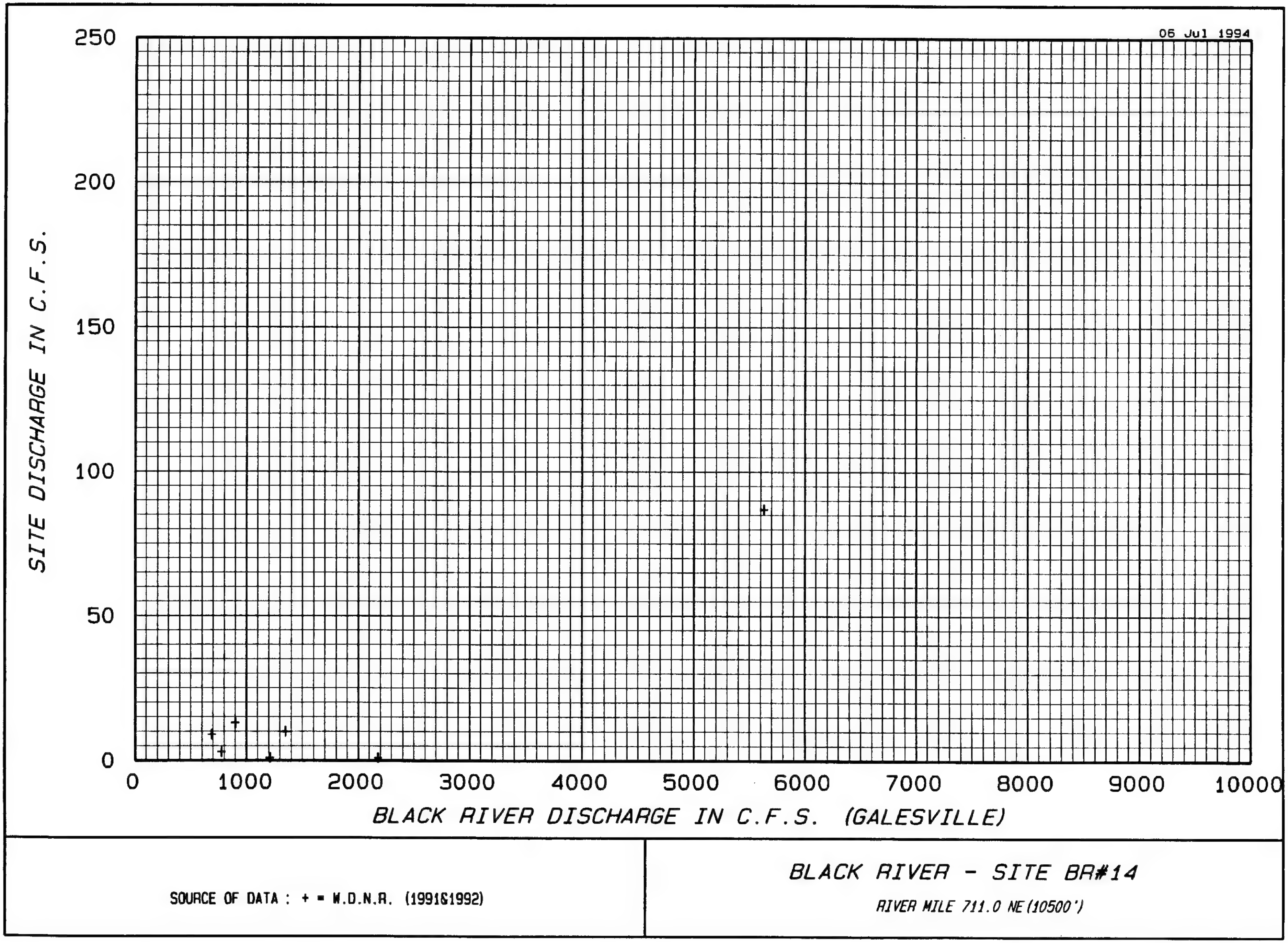

06 Jul 1994
250
200
150
100
50
0
SITE DISCHARGE IN C.F.S.
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
SOURCE OF DATA : + = W.D.N.R. (1991&1992)
BLACK RIVER - SITE BR#14
RIVER MILE 711.0 NE (10500')

Figure 24

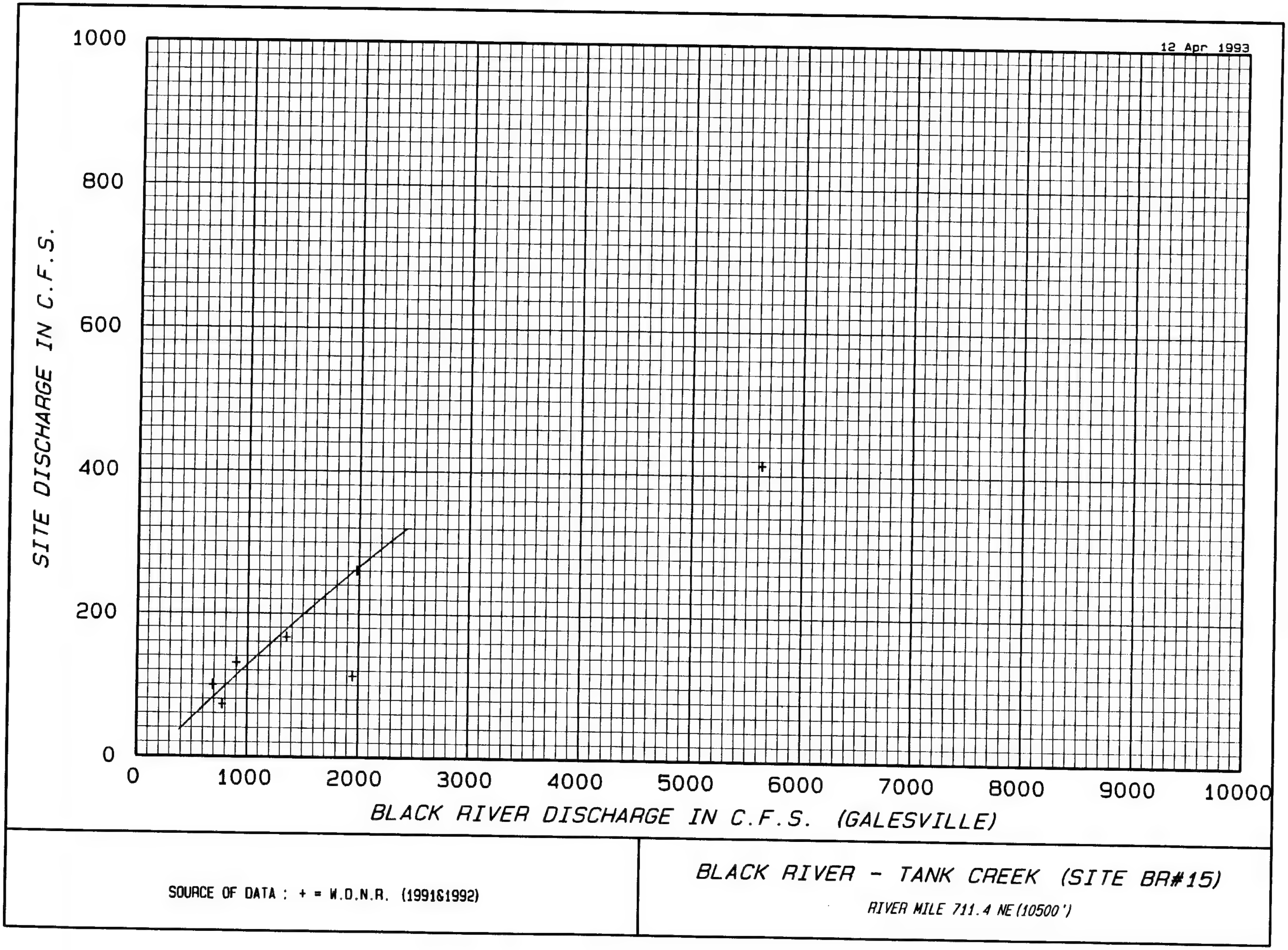

12 Apr 1993
SITE DISCHARGE IN C.F.S.
1000
800
600
400
200
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
SOURCE OF DATA : + = W.D.N.R. (1991&1992)
BLACK RIVER - TANK CREEK (SITE BR#15)
RIVER MILE 711.4 NE (10500')

Figure 25

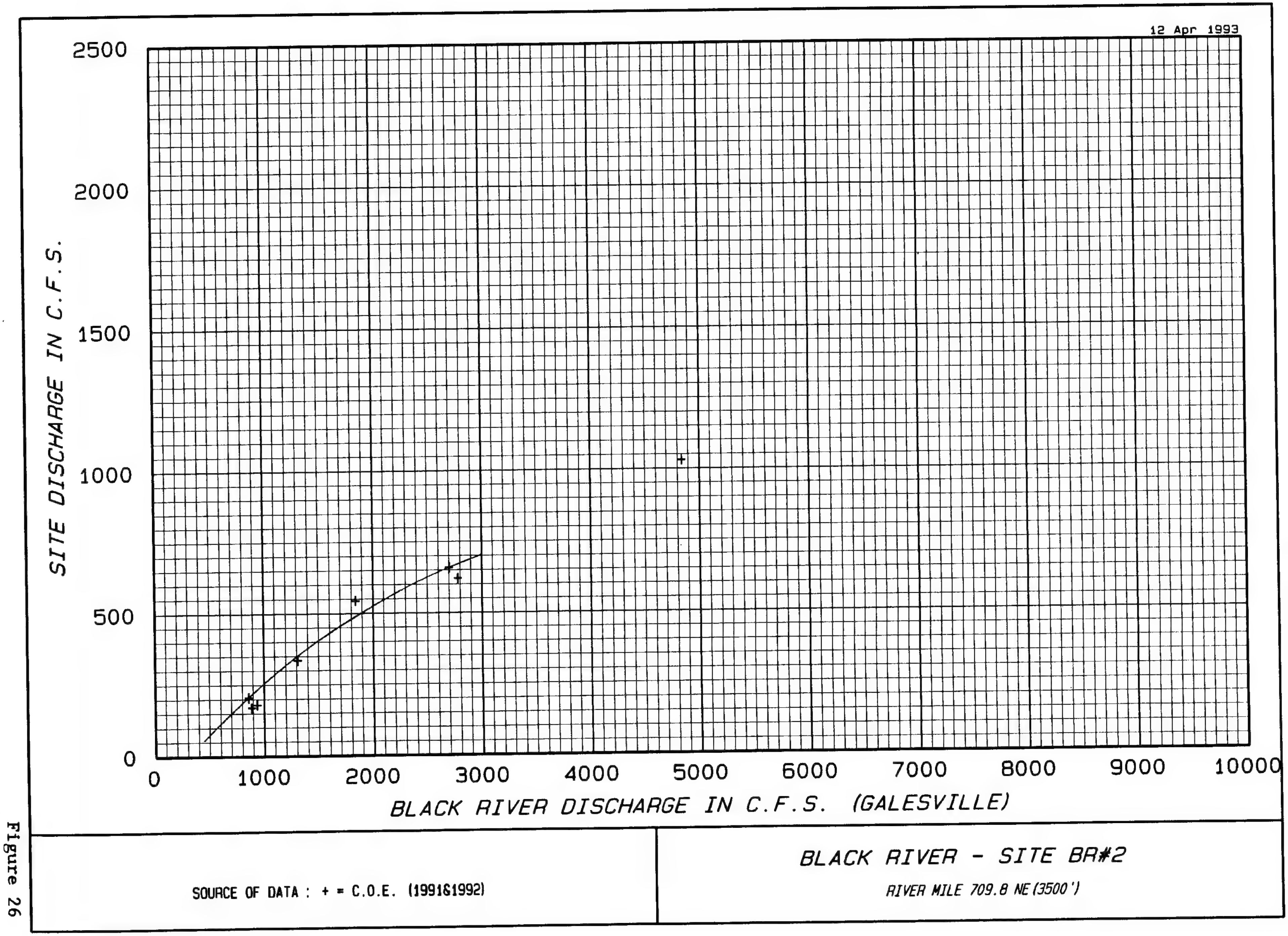

12 Apr 1993
2500
2000
1500
1000
500
0
SITE DISCHARGE IN C.F.S.
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
SOURCE OF DATA : + = C.O.E. (1991&1992)
BLACK RIVER - SITE BR#2
RIVER MILE 709.8 NE (3500')

Figure 26

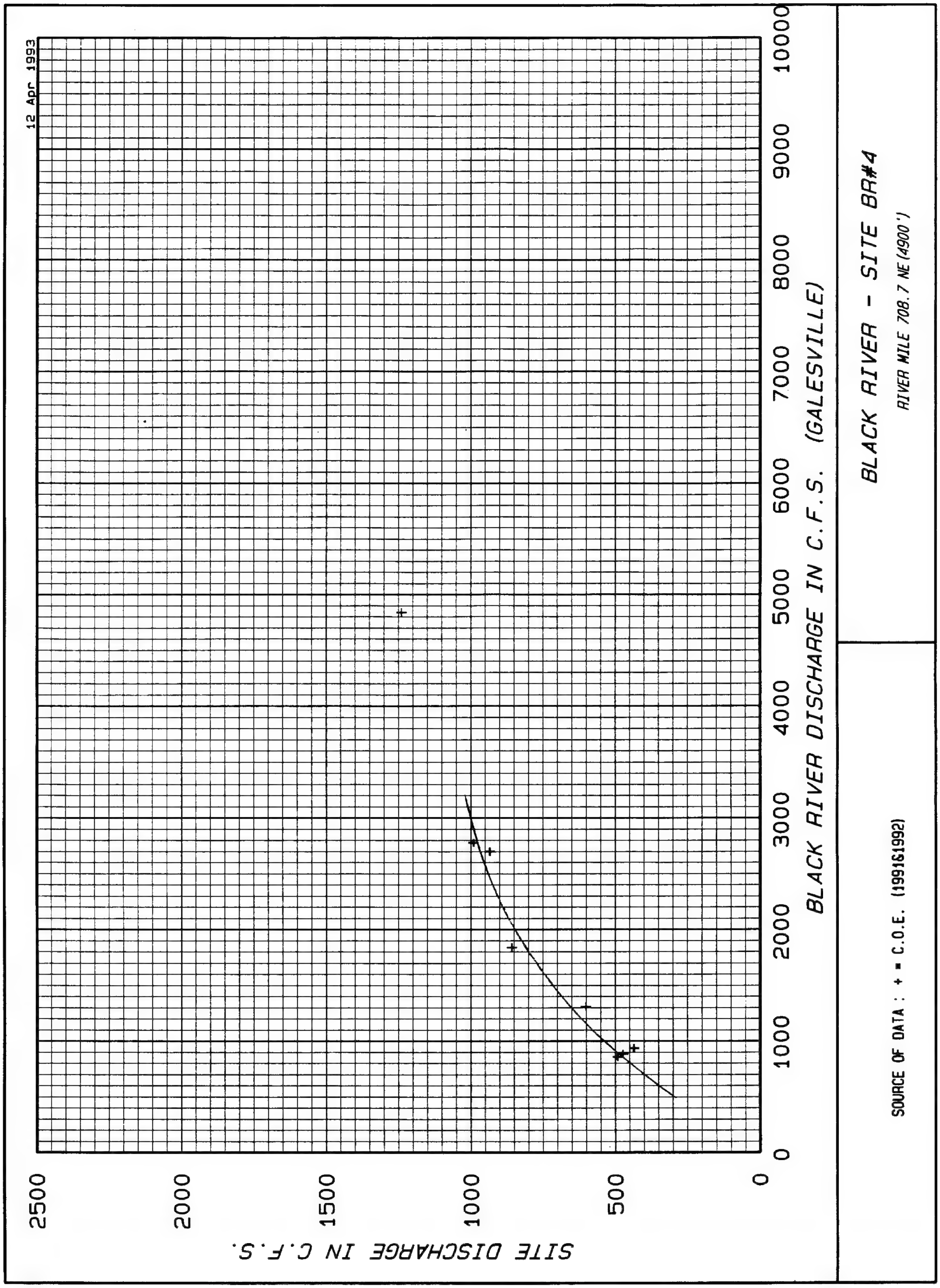
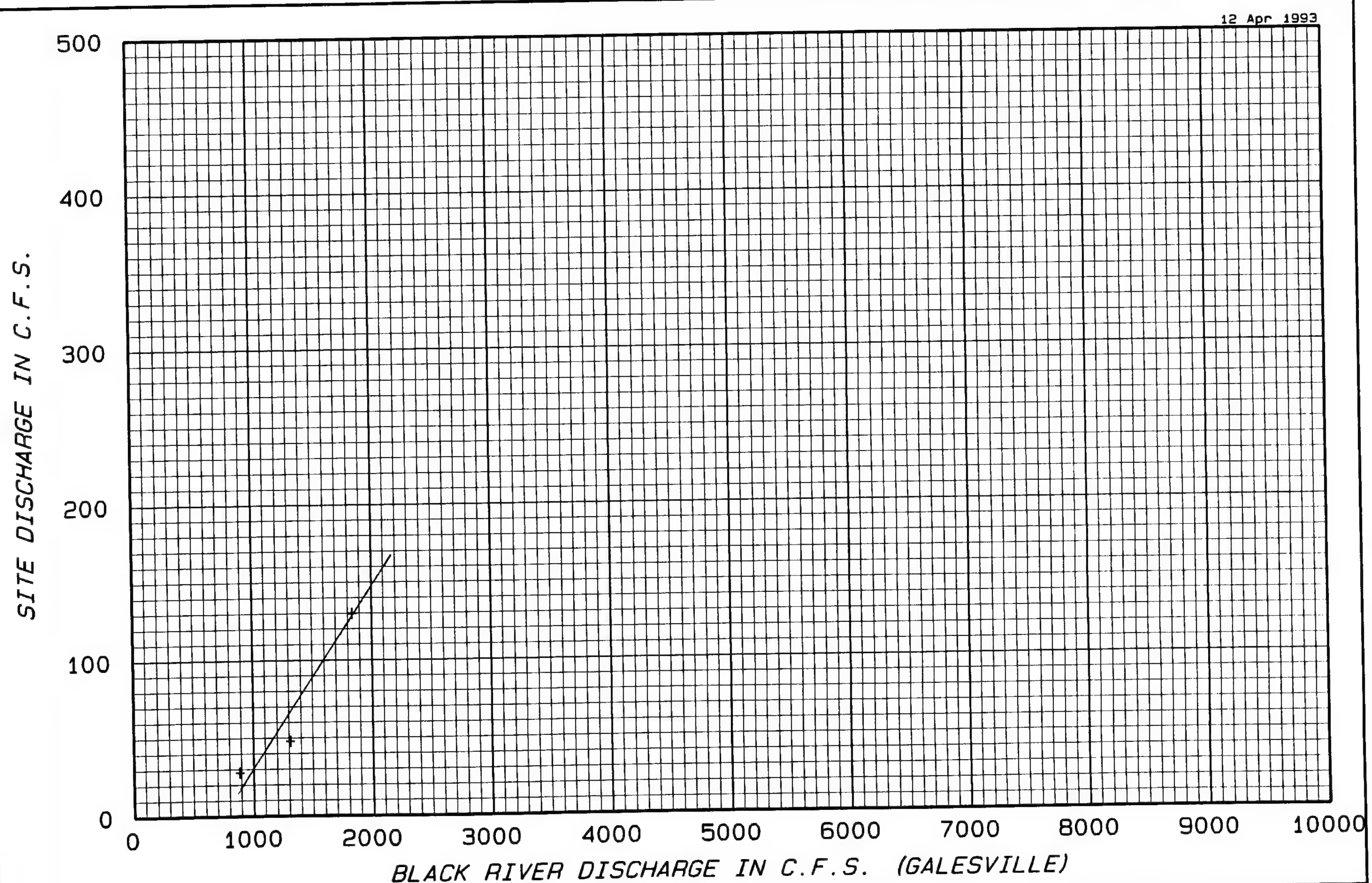

12 Apr 1993
2500
2000
1500
1000
500
0
SITE DISCHARGE IN C.F.S.
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
SOURCE OF DATA : + = C.O.E. (1991&1992)
BLACK RIVER - SITE BR#4
RIVER MILE 708.7 NE (4900')

Figure 27



SOURCE OF DATA : + = C.O.E. (1991&1992)

BLACK RIVER - SITE BR#5

RIVER MILE 709.6 NE (2800')

Figure 28

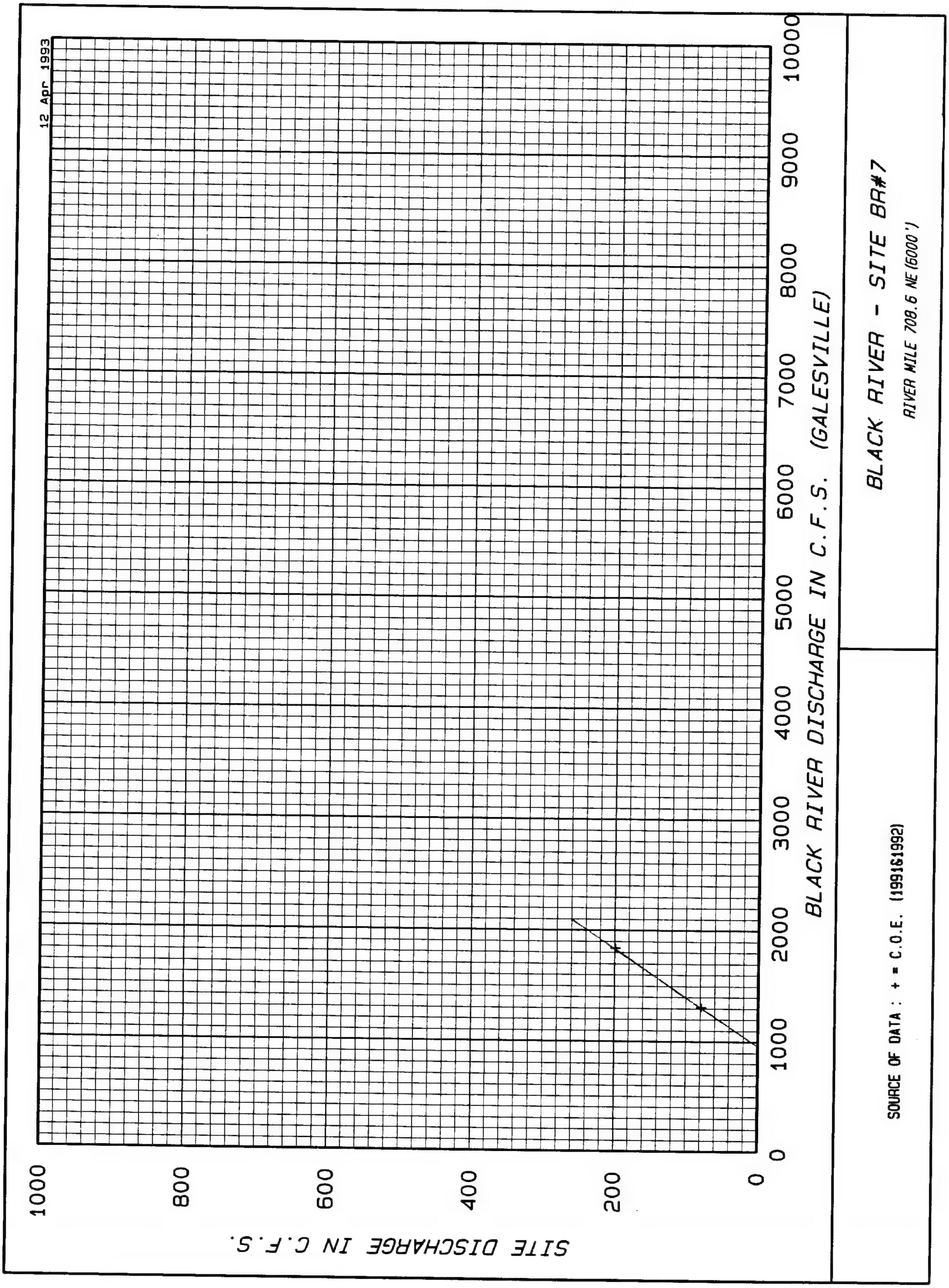

12 Apr 1993
SITE DISCHARGE IN C.F.S.
0
200
400
600
800
1000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
BLACK RIVER DISCHARGE IN C.F.S. (GALESVILLE)
BLACK RIVER - SITE BR#7
RIVER MILE 708.6 NE (6000')
SOURCE OF DATA : + = C.O.E. (1991&1992)

Figure 29

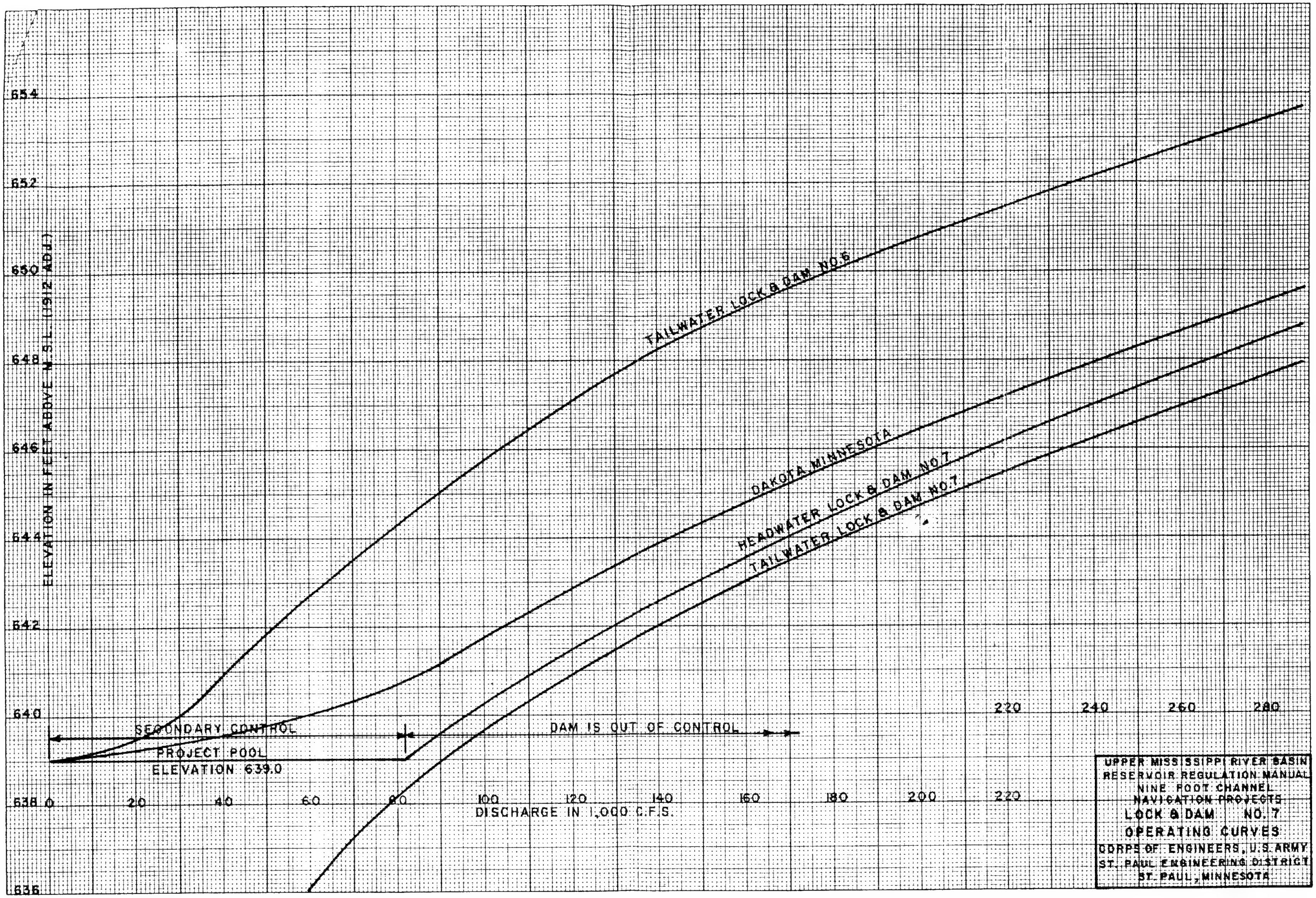

ELEVATION IN FEET ABOVE M.S.L. (1912 ADJ.)
654
652
650
648
646
644
642
640
638
636
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
DISCHARGE IN 1,000 C.F.S.
TAILWATER LOCK & DAM NO.6
DAKOTA, MINNESOTA
HEADWATER LOCK & DAM NO.7
TAILWATER LOCK & DAM NO.7
SECONDARY CONTROL
PROJECT POOL
ELEVATION 639.0
DAM IS OUT OF CONTROL
UPPER MISSISSIPPI RIVER BASIN
RESERVOIR REGULATION MANUAL
NINE FOOT CHANNEL
NAVIGATION PROJECTS
LOCK & DAM NO. 7
OPERATING CURVES
CORPS OF ENGINEERS, U.S. ARMY
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

Figure 30

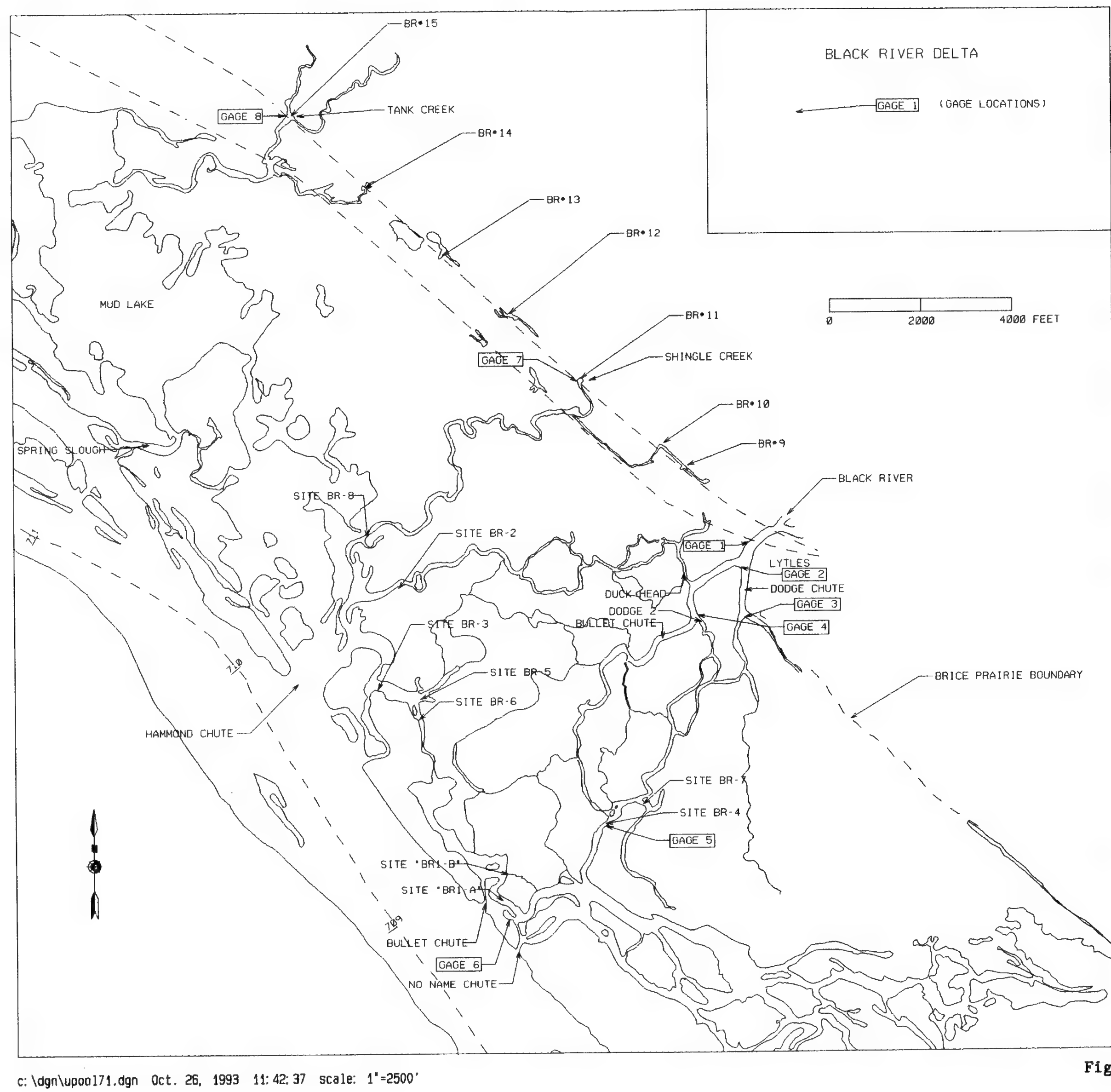

BLACK RIVER DELTA
GAGE 1 (GAGE LOCATIONS)
0
2000
4000 FEET
BR•15
GAGE 8
TANK CREEK
BR•14
BR•13
BR•12
MUD LAKE
BR•11
GAGE 7
SHINGLE CREEK
BR•10
BR•9
BLACK RIVER
SPRING SLOUGH
SITE BR-8
SITE BR-2
GAGE 1
LYTLES
GAGE 2
DODGE CHUTE
GAGE 3
GAGE 4
DUCK HEAD
DODGE 2
BULLET CHUTE
SITE BR-3
SITE BR-5
SITE BR-6
BRICE PRAIRIE BOUNDARY
HAMMOND CHUTE
SITE BR-4
GAGE 5
SITE 'BR1-B'
SITE 'BR1-A'
BULLET CHUTE
GAGE 6
NO NAME CHUTE
c:\dgn\upool71.dgn Oct. 26, 1993 11:42:37 scale: 1"=2500'

Figure 31

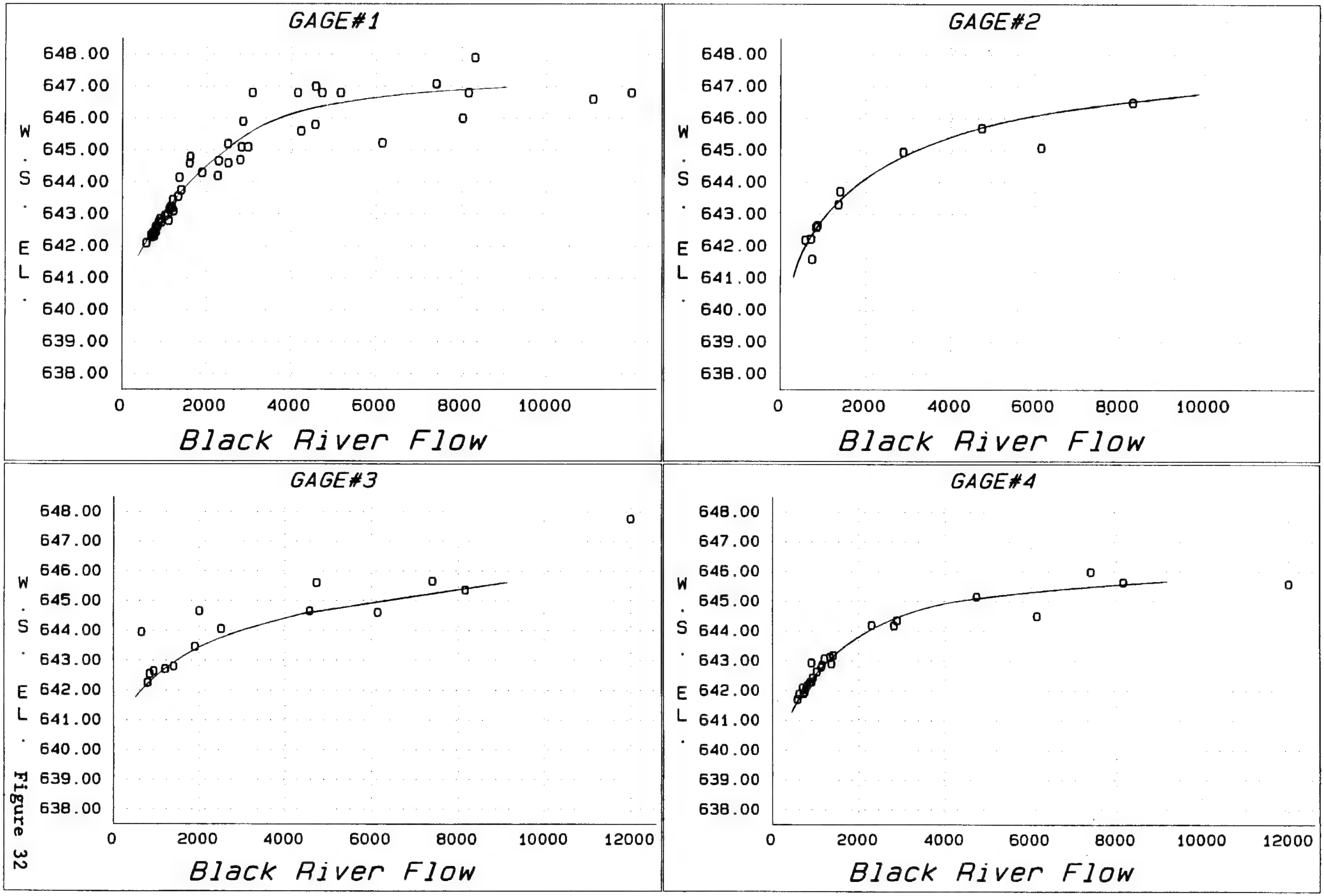

GAGE#1
GAGE#2
GAGE#3
GAGE#4
W.S. EL.
648.00
647.00
646.00
645.00
644.00
643.00
642.00
641.00
640.00
639.00
638.00
0
2000
4000
6000
8000
10000
12000
Black River Flow

Figure 32

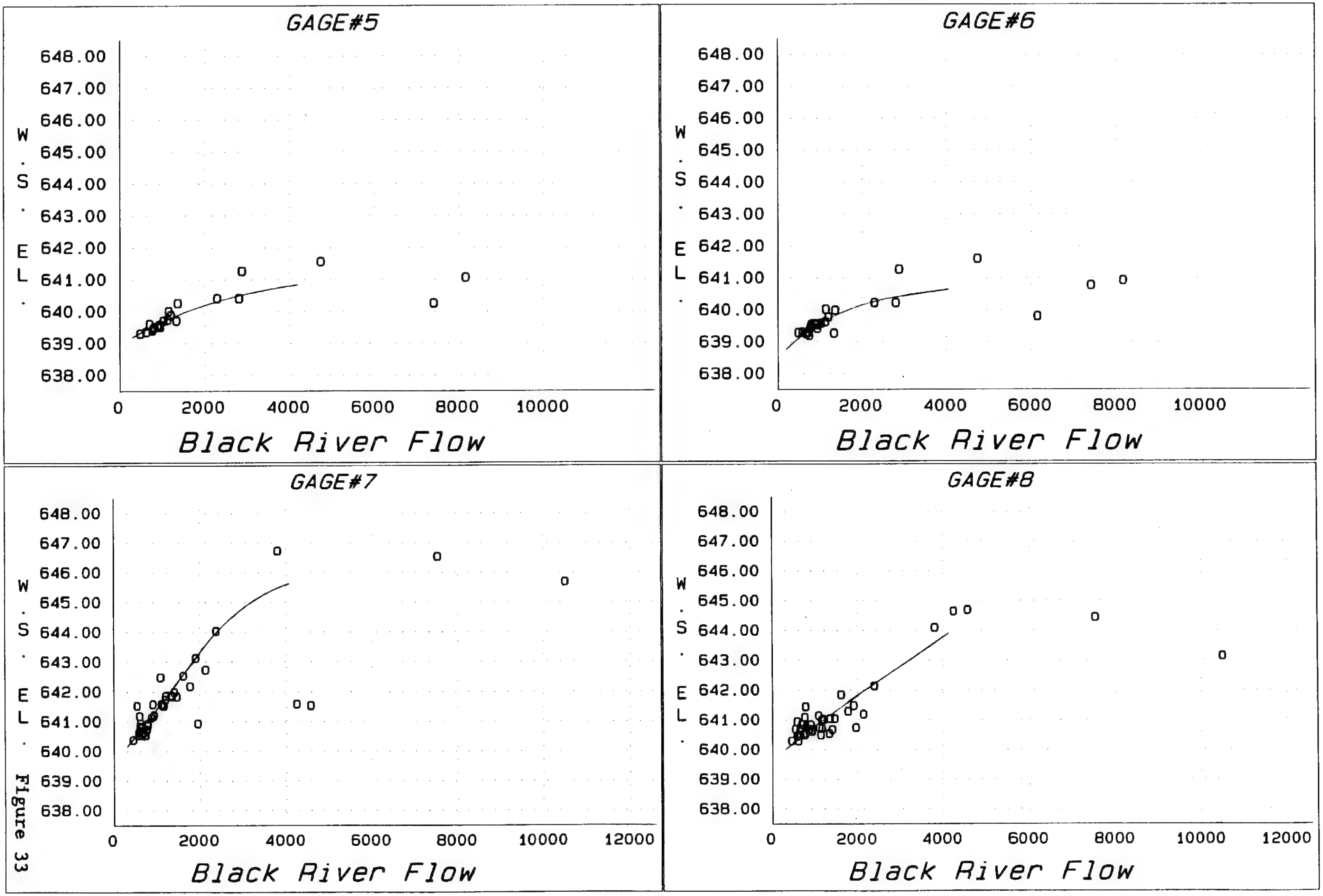

GAGE#5
GAGE#6
GAGE#7
GAGE#8
W.S. EL.
648.00
647.00
646.00
645.00
644.00
643.00
642.00
641.00
640.00
639.00
638.00
0
2000
4000
6000
8000
10000
12000
Black River Flow

Figure 33

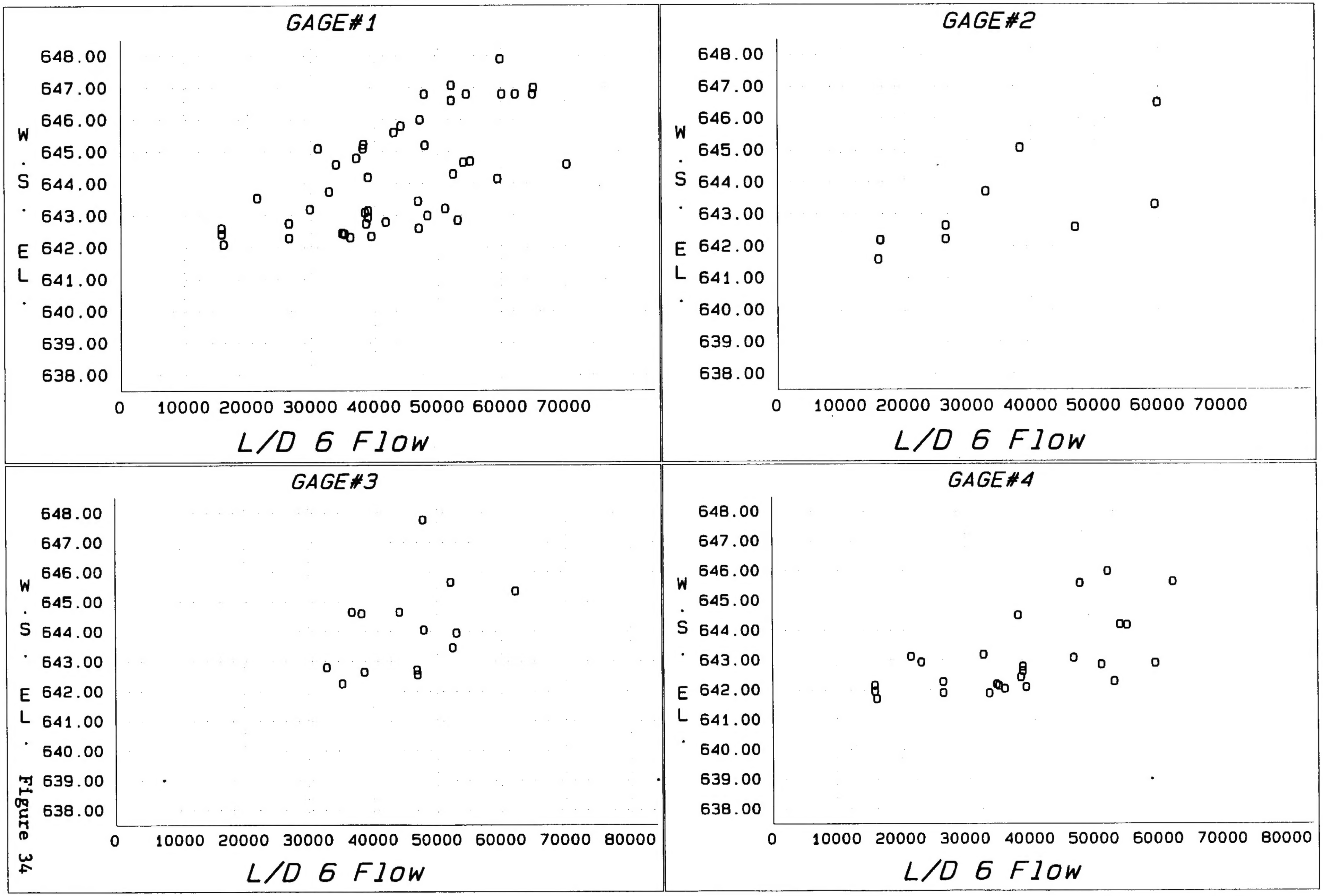

GAGE#1
GAGE#2
GAGE#3
GAGE#4
W.S. EL.
648.00
647.00
646.00
645.00
644.00
643.00
642.00
641.00
640.00
639.00
638.00
0
10000
20000
30000
40000
50000
60000
70000
80000
L/D 6 Flow

Figure 34

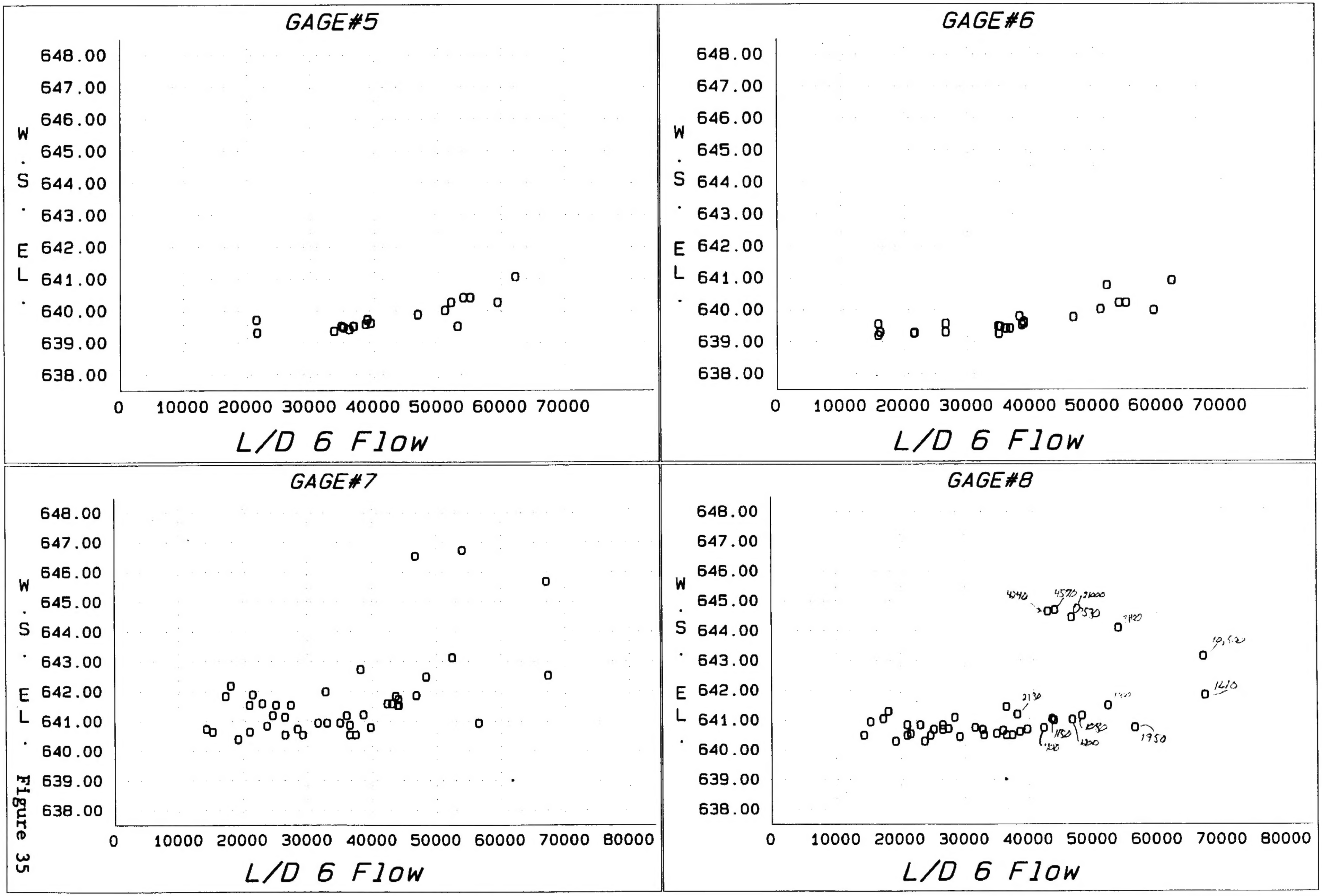

GAGE#5
GAGE#6
GAGE#7
GAGE#8
W.S. EL.
648.00
647.00
646.00
645.00
644.00
643.00
642.00
641.00
640.00
639.00
638.00
0
10000
20000
30000
40000
50000
60000
70000
80000
L/D 6 Flow

Figure 35

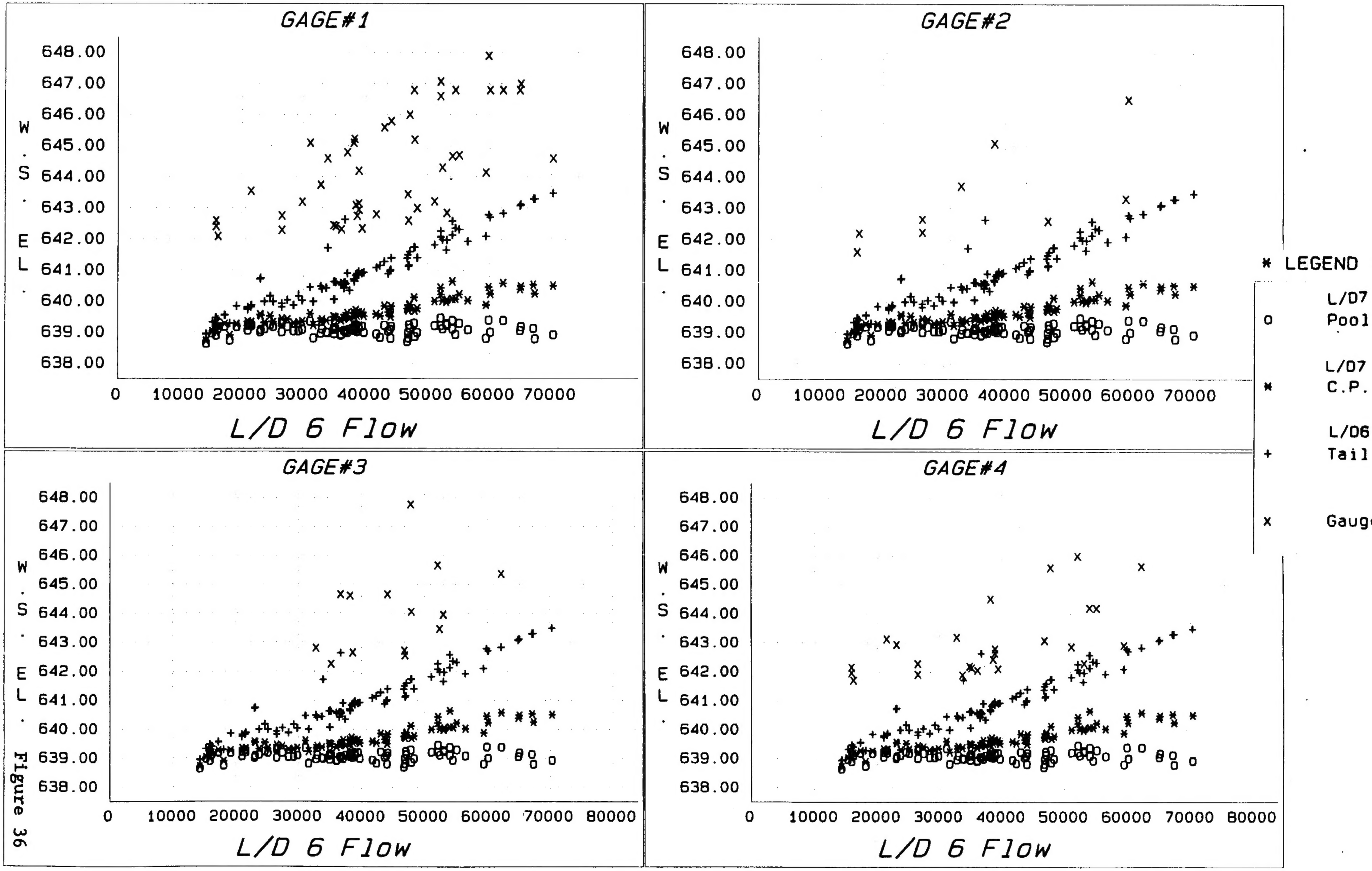

GAGE#1
GAGE#2
GAGE#3
GAGE#4
W.S. EL.
648.00
647.00
646.00
645.00
644.00
643.00
642.00
641.00
640.00
639.00
638.00
0
10000
20000
30000
40000
50000
60000
70000
80000
L/D 6 Flow
LEGEND
L/D7 Pool
L/D7 C.P.
L/D6 Tail
Gauge

Figure 36

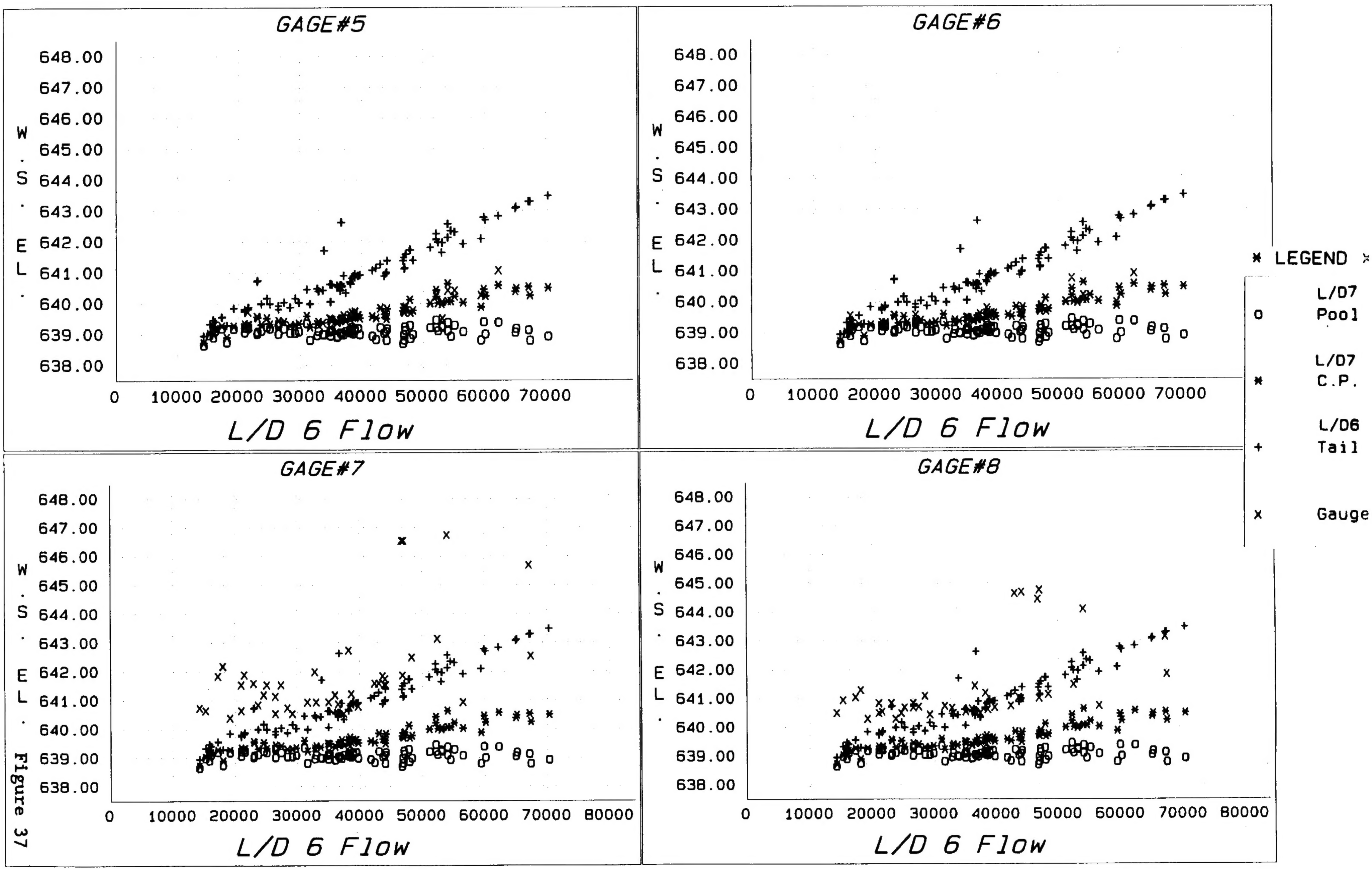

GAGE#5
GAGE#6
GAGE#7
GAGE#8
W.S. EL.
L/D 6 Flow
LEGEND
L/D7 Pool
L/D7 C.P.
L/D6 Tail
Gauge
648.00
647.00
646.00
645.00
644.00
643.00
642.00
641.00
640.00
639.00
638.00
0
10000
20000
30000
40000
50000
60000
70000
80000

Figure 37